GAZOS CREEK ASSESSMENT AND ENHANCEMENT PLAN, SAN MATEO COUNTY, CALIFORNIA

FISHERY ASSESSMENT

Prepared by

D.W. ALLEY & Associates
P.O. Box 200
Brookdale, California 95007-0200

Prepared for the

Coastal Watershed Council
California Coastal Conservancy
California Department of Fish and Game

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Summary of Findings Related to the Fishery Resource

Gazos Creek is inhabited by both coho salmon (Federally listed as Threatened; State listed as Endangered) and steelhead (Federally listed as Threatened). Only 1 of 3 coho year classes (1993, 1996, 1999, 2002) is now present in Gazos Creek. Another was weak in 1995 and 1998 and missing in 2001, and the third year class (1997, 2000) is missing (**Smith 2001b; 2002**). With two of its three year-classes gone, the Gazos Creek coho population is at risk of extinction. Because similar situations exist in adjacent watersheds, little help may be expected from natural strays of those watersheds to restore these year classes in Gazos Creek. Weak or absent year classes have resulted from severe droughts and floods over the past 18-25 years (**Smith 1994; 2001b**).

Juvenile coho had been captured almost exclusively in relatively deep, complex pools of Gazos Creek until 2002 (**Smith 2001b; 2002**). From Smith's historical sampling of Gazos Creek that began in 1992, it was determined that coho juveniles used primarily Reaches 5 and 6 through the 2001 sampling (**Smith 2001b**). However, in 2002 coho densities were 4 times the 1999 density. They were found at all sampled sites below the chute at the beginning of Reach 7 (channel mile 6.5), in pools widely varying in complexity and depth, as well as in some glides (**Smith 2002**), although they were least abundant downstream of Old Woman's Creek. Woody debris was important in creating pool complexity and scour. In 1998 on Gazos, Scott and Waddell creeks, most of the scarce juvenile coho were captured near logjams that would have protected newly-emerged fry from heavy spring flows that occurred that year (**Smith 1998**).

The California Department of Fish and Game (CDFG) sampled pools in Gazos Creek (including one run) in late October 1995 (**Nelson 1996**). Nine stations were sampled throughout the lower 5 miles. Juvenile steelhead were captured at all stations. One juvenile coho was captured at Station 7, channel mile 4.0 (Reach 5A). Prickly and coastrange sculpins, threespine sticklebacks and Pacific giant salamander larvae were also captured.

Densities of young-of-the-year steelhead tend to increase with more summer baseflow in smaller Central Coast stream reaches where two years are required to reach smolt size and spawning success is not limiting (**Alley 2001a; Alley et al. 2003b**). This is because steelhead utilize fastwater habitat that is more abundant in wetter years. However, annual sampling since 1992 has shown wide year-to-year variation in coho abundance in Gazos, Waddell and Scott creeks, south of San Francisco Bay (**Smith 2001a**), Although the sampling and analysis did not quantitatively describe the relationship between coho abundance and baseflow, it seems likely that most of the variation in abundance is attributable to factors other than baseflow. According to Smith (**2001a**), these wide differences in annual abundance occur because the restricted early spawning period, single spawning attempt, and rigid ages of smolting and spawning (**Shapovalov and Taft 1954**) make them susceptible to drought, floods or other disasters within small watersheds (**Smith 1994**). Coho in these small Central Coast streams apparently could not take advantage of expanded fastwater habitat as steelhead do in higher baseflow years because coho are primarily pool-dwelling fish. In addition, in the high baseflow year of 1998 or any other year with large, late winter storms, coho egg survival was likely very low with their spawning period being earlier than steelhead, thus overshadowing any potential benefit from high summer baseflow to overall coho abundance. Even so, baseflow in the spring may be expected to greatly influence food abundance and growth of juvenile coho in pools, with more growth expected with higher spring baseflow. In larger drainages inhabited by coho further north, higher summer baseflow may be sufficiently high to enhance coho growth even in summer. Since steelhead are present in all local coho streams and although the observed wide year-to-year variation in coho abundance (Smith 2001a) is likely attributable to factors other than baseflow, summer baseflow must be protected to maximize the quality and quantity of habitat for both species. Weak or non-existent coho year classes and other factors, such as fluctuations in spawning success, make this lack of correlation between coho abundance and summer baseflow impossible to confirm for Gazos Creek, but the pattern generally holds for Scott Creek (**Smith 1999**).

According to Smith, the relatively high, stable abundances of young–of-the-year (YOY) steelhead over the years in Gazos Creek and nearby Scott and Waddell creeks indicate that adult steelhead numbers and spawning success have not been a problem in limiting YOY production in these small coastal watersheds. Generally, the highest overall YOY steelhead abundance at most sampling sites in Gazos Creek had been in years of highest summer streamflow, 1995, 1998 and 1999**,** thus making summer baseflow an important factor for this species. This positive relationship occurs because YOY steelhead can utilize runs and shallow riffles in wetter years. Yearlings, which prefer deep, complex pools have their numbers generally controlled by structure that scours pools and creates escape cover. On the other hand, yearling steelhead densities in the fall had declined since 1997 in Gazos Creek, as well as Scott and Waddell creeks. This may have resulted from severe winter storms that washed juveniles out to sea and/or more rapid growth due to high springtime flows that allowed more YOY's to grow sufficiently to smolt and out-migrate as young yearlings in late spring, thus avoiding capture during the next fall sampling. Yearlings made a rebound in 2001, perhaps due to a milder winter with less over-winter mortality.

YOY steelhead densities in the past 3 years have generally been lowest in Reach 1, downstream of Old Woman's Creek, and have increased upstream to their highest densities in Reach 5A-B (**Figure 21**). Densities at the site in Reach 5C have been generally lower than at adjacent sites in Reaches 5A-B and 6 due to heavy shading. Yearling densities showed no obvious relationship with streamflow or location in the watershed (**Figure 21**).

Low YOY densities downstream of Old Woman's Creek may occur because of the reduced substrate quality due to more sandy conditions and frequent coating with more silt in that reach (**Smith 2001b**). Increased sedimentation and more highly shaded conditions likely reduce aquatic insect abundance and feeding efficiency upon drifting insects, resulting in reduced food supply for rearing fish. YOY abundance has generally been lower in very shady locations (canopy closures of 95+%) (**Smith 2001b**). Increased sedimentation may also reduce spawning attempts and spawning success downstream of Old Woman's Creek. Another upstream tributary, the South Fork (Bear Gulch), has been utilized by steelhead in its lower portion.

Although YOY steelhead abundance is lowest below the Old Woman's Creek confluence, yearling densities there were similar to other reaches (**Figure 21**). Annual yearling densities were similar between all mainstem reaches, although they were lower in middle reaches in 1998 possibly due to over-winter mortality during flood flows. Production of smolt-sized yearlings is more critical to determining numbers of returning adult steelhead than production of smaller YOY fish.

FIELD METHODS FOR SALMONID HABITAT ASSESSMENT, 2001

Classification of Habitat Types and Measurement of Habitat Characteristics

The purpose of habitat analysis was to characterize the primary reaches used by coho salmon and identify limiting factors for coho and steelhead. Dr. Jerry Smith has provided 7 reach designations with Reach 5 divided into 3 segments, which were taken into account. Reach 1 began at Highway 1 and ended at the Old Woman's Creek (OWC) confluence (**Figure 1 in Gazos Creek Watershed Enhancement Plan**). Reach 2 went from OWC to road mile 2.8. The short Reach 3 went from road mile 2.8 to 3.0 (there was a dead fir across the channel) and was influenced by 1998 logjams and resulting channel deposition (EPA sites G-I). The short Reach 4 went from road mile 3 to 3.15 where the channel became very entrenched (just downstream of an unnamed tributary). Reach 5 had an A, B, and C, differing in shade and entrenchment. Reaches 5A and 5B were combined during this analysis, extending to just beyond the former logjam at EPA Site Q. Reach 5C went to the South Fork (Bear Gulch) confluence. Reach 6 extended up to the steep bedrock chutes around the bend upstream of the bridge crossing. Reach 7 went to the chute just upstream of the Middle Fork confluence. Except where mentioned, reach boundaries were not correlated with road mile.

Approximately 5.5 miles of the lower 6.7 miles of Gazos Creek from Highway 1 to the steep bedrock chute beyond the Middle Fork confluence were surveyed and habitat typed, with the exception of two segments in Reach 1. The segment between Highway 1 and the water diversions (approximately 1,800 feet) was not surveyed, and a 3,700-foot segment immediately downstream of the Old Woman's Creek confluence was surveyed for large woody debris only. The middle 7,500 feet of Reach 1 was surveyed to determine stream characteristics. The portion of Reach 1 from the lagoon to the water diversion was not habitat typed because habitat values there are subject to variation due to variable surface water diversion and shallow well pumping. Thus habitat values below the diversion would not be consistent with the remainder or Reach 1. Also, the extent of stream habitat would vary depending on whether the sandbar was intact or not. Thirdly, it was reported that the odor of raw sewage permeated the air near the lagoon (**M. Leicester, personal communication**), indicating a potential health hazard and danger to the field biologist if he waded the creek in that area.

The South Fork (Bear Gulch) was surveyed to impassable barriers to anadromy. Reach delineations during the habitat survey were determined by Jerry Smith based primarily on changes in geomorphology and gradient, with changes in entrenchment and channel type. Beginning at Highway 1, reaches used in this habitat survey were as follows; Reach 1 (13,335 feet), Reach 2 (4,478 feet), Reach 3 (1,779 feet), Reach 4 (876 feet), Reaches 5A and 5B combined (7,618 feet), Reach 5C (3,946 feet), Reach 6 (2,355 feet) and Reach 7 (981 feet). Survey of habitat on the South Fork (Bear Gulch) consisted of the anadromous Reach 1 to the first passage impediment (915 feet). Habitat proportions were determined by reach, as was channel type.

Habitat types were classified according to the categories outlined in the California Salmonid Stream Habitat Restoration Manual (**Flosi et al. 1998**). A modified CDFG Level III habitat inventory method was used. All habitat units were classified according to habitat type and their lengths were measured. Pools are the primary habitat for coho salmon and yearling steelhead in Gazos Creek, and have the greatest potential for enhancement. All pool units were measured for maximum depth, mean depth and mean width, with visual estimates of dominant substrate composing the tail of the pool (or glide at the tail of the pool), percent fines for the pool and embeddedness at the tail for many pools. Every third to fifth pool unit (depending on time constraints), beginning with the first pool encountered in the reach, was additionally measured for escape cover and canopy closure, with a visual estimate of cobble embeddedness for cobble larger than 6 inches (150 mm). Canopy closure was measured with a spherical densiometer. Percent deciduous/conifer canopy was visually estimated along with canopy closure. Other team members performed a more detailed survey of the riparian corridor.

For non-pool habitat types, the first encounter of each habitat type in the reach and every third to fifth habitat unit (depending on time constraints) of each type thereafter was measured for maximum depth, average depth, average width, embeddedness and escape cover. The scour objects that created pools were determined and tallied in each reach. In the wetted channel, all woody material at least a foot in diameter was inventoried by habitat for the number of logs/ rootwads found in the wetted channel, along with their species, estimated trunk diameter and length. Michelle Leicester performed a more detailed wood survey above the wetted channel.

Streamflow was measured by Coastal Watershed Council volunteers and personnel from Balance Hydrologics in Reaches 1, 2, 5C, above 7, South Fork and Middle Fork in 2001.

Inventory of Streambank Erosion

Locations of streambank erosion were measured and inventoried during the stream survey in each of the reaches up to the North and Middle Fork confluences. Streambank erosion sites were photo-documented and measured for length, average height, and percent vegetated. The erosion site was classified as active or inactive. The cause of the bank failure was stated, and a GPS reading was taken, if possible. The channel location was determined by hip chain measurement during the survey. Other team members documented sources of erosion in detail.

Inventory of Salmonid Passage Impediments for Spawning

The North Fork, upstream of the Middle Fork confluence, was surveyed for barriers to salmonid spawning migration. The survey ended where the frequency of barriers and the lack of habitat between them were such that barrier modification was judged far too difficult to provide adequate returns in terms of additional fish habitat. Parameters measured at chutes that created passage impediments included wetted channel width, length of the chute and maximum and average water depth on the day of survey. Chutes in Gazos Creek were bedrock ramps, which were generally flat, wide and consistently shallow across.

At passage impediments that involved cascades and waterfalls, measurements were taken for the height of the jump from the water surface on the day of the survey and estimated for bankfull conditions. Other measurements were the maximum water depth and length of the approach to the jump on the day of the survey and estimates for bankfull conditions. The channel width on the day of the survey and at bankfull and estimated streamflow required for passage over the impediment were estimated. The locations of the passage impediments were measured with GPS and measured in distance from the north and South Fork confluences. Passage impediments were photo-documented.

Inventory of Large Woody Material in the Wetted Channel

During our survey work, all large woody material (1 foot or greater in diameter and 6 feet or greater in length) in the low flow (wetted) channel was measured and counted in the 7 mainstream, anadromous reaches of Gazos Creek. This included only wood actually in the water. Note was taken as to whether the wood had been cut or not. Bar graphs were developed to summarize the findings (**Table 1; Figures 1-8**). An in-depth inventory of large woody material adjacent to and within the channel was carried out by Leicester (**2002**).

FISHERY HABITAT CHARACTERISTICS

The habitat survey in 2001 came 3 years after the high El Niño stormflows and a long history of logjam maintenance (**Smith 2002**) involving cutting of trees into smaller pieces in locations where jams might threaten the adjacent road with streambank erosion.

Channel Typing

Channel types determined by Dr. Jerry Smith for reaches of the mainstem were as follows; Reach 1 (C5), Reach 2 (C4), Reach 3 (B4c), Reach 4 (B4c), Reach 5A (B4c/F4), Reach 5B (B4c), Reach 5C (B4c), Reach 6 (B1), Reach 7 (A1) and above Reach 7 on the North Fork (B3).

According to Rosgen (**1996**), the "A" stream type flows through steep, narrow valleys having a slope range of 4-10%. The A stream has a low bankfull width/depth ratio and is totally confined and laterally contained with low sinuosity less than 1.2. The bedforms are often step/pool morphology with chutes, debris flows and waterfalls. A-channels have high sediment transport potential and a relatively low in-channel sediment storage capacity. The number after the A indicates the coarseness of the dominant bed material and the steepness of the adjacent slopes. The A1 channel is bedrock controlled with steep slopes and channels. The bed material is dominated by bedrock with lesser amounts of boulders, cobble and gravel.

According to Rosgen (**1996**), the "B" stream type travels through narrow valleys that limit development of wide floodplains. Often B stream channels result from influences of structural contact zones, faults, joints, colluvial-alluvial deposits and structurally controlled valley side-slopes. B streams are moderately entrenched, have a cross-section width/depth ratio at bankfull of greater than 12, low channel sinuosity, and are dominated by "rapids" bed morphology and a slope range of 0.02 and 0.04 (2-4%). Streambank erosion rates are normally low, as are rates of channel aggradation and degradation. Meander width ratios (belt width/bankfull width) are generally low. B3 channels are in narrow, moderately steep colluvial valleys with gentle side slopes. Soils are colluvium and/or alluvium. Channel materials are dominated by cobble with lesser amounts of boulders, gravel and sand. B4 channels are dominated by gravel with lesser amounts of boulder, cobble and sand and have moderately steep colluvial valleys. A B4c channel has a gentle slope of less than 2%.

According to Rosgen (**1996**), the "C" stream type is located in narrow to wide valleys made from alluvial deposition. C stream channels have well-developed floodplains, are slightly entrenched, are relatively sinuous, have a channel slope of 2% (0.02) or less and a bedform morphology in a steep riffle/flat pool pattern. C stream types have cross-sectional width/depth ratios generally greater than 12, with sinuosities greater than 1.4. Point bars are common and the aggradation/degradation and lateral extension of the channel are dependent on the stability of streambanks, existing upstream watershed conditions and flow and sediment regime. The C channel can be easily destabilized by changes in bank stability, watershed conditions or flow regime. A C4 channel has a bed dominated by gravel with lesser amounts of cobble, sand and silt/clay. C5 channels have mainly sandbeds and banks, with occasional gravel and silt/clay. Streambanks may contain finer particles than the bed material.

According to Rosgen (**1996**), the "F" channel type is entrenched and meandering through valleys of relatively low elevational relief containing highly weathered rock and/or erodible materials. F stream channels have high bankfull width/depth ratios, high sinuosity >1.4 and gentle channel slopes <2%. They develop very high bank erosion rates, lateral extension rates, significant bar deposition and accelerated channel aggradation and/or degradation. They provide for very high sediment supply and storage capacities. The F4 channel is deeply entrenched and associated with highly weathered bedrock or depositional soils involved in stream downcutting and sometimes uplift of valley walls. Its bed is dominated by cobble and sand. Streambanks are generally eroding unless stabilized with thick riparian vegetation.

Wood Inventory and Pool Formation

In 2001, pools formed by woody debris dominated the pool habitat in 4 of the 7 anadromous salmonid reaches of mainstem Gazos Creek and in the South Fork (Bear Gulch). In the mainstem, 184 of 327 inventoried pools (56%) were scoured and formed by woody debris. Leicester (**2002**) found that pools and backwaters were primarily formed by relatively scarce, large conifer logs and rootwads (greater than 2 feet in diameter and 20 feet in length). In the South Fork (Bear Gulch), 9 of 42 were woody debris pools (21%). Cut logs and cut stumps comprised a significant portion of the large woody debris in the low-flow channel. Many rootwads originating from old growth redwoods presumably cut down for lumber early on still remain in the stream channel. Leicester (**2002**) found that most of the conifer-derived large woody debris (LWD) in the channel was old redwood derived from past logging or logjam clearing activities that had resulted in cutting of that old redwood. Because in-channel woody debris is responsible for such a significant portion of the salmonid rearing and overwintering habitat in Gazos Creek, management of the factors that influence its supply to the channel is critical. Leicester (**2002**) found that recruitment sources of new LWD were primarily perched, dead/standing and/or leaning trees that were mostly small hardwoods (mainly red alder) less than 2 feet in diameter. Very few dead/standing or leaning conifers were present, and most of them were not likely to be recruited because they were upslope or further back in the riparian zone away from the creek.

<u>Wood and Coho Success</u>

Because coho fry emerge from the gravels earlier than steelhead, spring storms can wash them from stream reaches lacking in backwaters or other complex habitats provided by woody material. The high densities of coho found in 2002 at all sites (**Smith 2002**) underscored the great potential for coho production when spawning success is high and spring fry survival is good due to early fall/winter storms and the absence of later storms. Large woody material was a major source of scour for pool development in Reaches 1-5C and a major provider of escape cover in pools utilized by coho salmon and steelhead (**Tables 1-6**). Coho had been captured primarily in deep, complex pools until 2002, when they were found in pools with a wide range of complexity and depth, as well as in some glides (**Smith 2002**). Though some complex pools existed, as indicated by high amounts of escape cover, most pools had limited escape cover (**Figure 15**).

<u>Wood and Rearing Habitat Quality</u>

Water depth and the amount of escape cover in pools are the two most important habitat parameters for determining summer rearing habitat quality. Woody material and escape cover in pools throughout Gazos Creek were generally higher than have been observed in either the San Lorenzo River or Soquel Creek watersheds (**Figure 10**) (**Alley 2001a; 2001b**). The Gazos Creek average cover index for reaches was just greater than 0.16 (16 feet of linear cover per 100 feet of stream), while the average for San Lorenzo tributaries was about 0.14. The escape cover level in Gazos Creek was similar to that in Santa Rosa Creek in San Luis Obispo County (**Alley 2001c**). The more escape cover the better is the habitat quality. Coho juveniles apparently need greater complexity and cover than steelhead because coho are uncommon in bedrock pools having limited cover, and coho greatly benefit from overwintering shelter provided by in-channel wood. Before 2002, coho were primarily found in the most complex pools. For steelhead streams, the cover index for pools typically ranges between 0.04 and 0.20. If the index is greater than 0.15, then escape cover is better than average. When the index rises above 0.25, cover is quite good and is usually associated with an undercut bank plus other cover objects such as boulders or wood. Large woody material in the wetted channel of Reach 1 was primarily deciduous hardwood in origin (**Figure 1**). Large woody material in the wetted channel of the middle reaches (2-6) of Gazos Creek, and overall, was primarily coniferous (**Figures 2-9**), with cut redwood stumps and logs being a significant proportion in Reaches 5A-B and 5C, along with old-growth redwood rootwads. Considerable cut wood had collected above the low-flow (wetted) channel, some of which was within the bankfull channel and some of it was in the flood plain (having been deposited by past large flood flows). Refer to **Table 1** for a summary of inventoried large wood in the low-flow channel.

In the lower 7 of 8 mainstem reaches in 2001, wood-scoured pools made up between 35% and 74% of the pool habitat per reach. In Reach 5C, where the frequency of large pieces of wood was highest, averaged mean pool depth was also highest of any reach in Gazos Creek. Water depth in reaches where pools were dominated by wood or scoured by rootwads of standing trees (Reaches 1-5C) was typical of other Central Coast streams of similar size in non-bedrock dominated reaches, such as certain reaches of tributaries of the San Lorenzo River (**Figure 9**) (**Alley 2001a**). Average water depth in Gazos Creek ranged between 1.2 and 1.5 feet in Reaches 1-5C, while maximum depth ranged between 1.7 and 2.0 feet in those reaches. Regarding habitat quality, the deeper the pools the better they are for rearing. When water depth becomes 2-3 feet deep, it offers cover value itself. Optimally, pools would average at least 2 feet in depth and be greater than 3 feet maximum depth. For small Central Coast streams, such as Gazos Creek, average pool depth of 1.2 feet and maximum pool depth of 2.0 feet are probably sufficient. However, a more shallow pool with more cover from possibly an undercut bank may provide more habitat than a deeper pool with less cover, such as a bedrock pool. Fastwater habitat in Gazos Creek was too shallow to provide habitat for smolt-sized juveniles (greater than 3 inches Standard Length) and provided very limited habitat for young-of-the-year steelhead. Coho would inhabit pools almost exclusively. Fastwater habitat must have pockets at least 0.6-0.8 feet deep before they produce significant numbers of young-of-the-year fish.

Table 1. Density of Large Woody Material in the Low Flow (Wetted) Channel, Inventoried by Reach in Mainstem Gazos Creek, 2001.

Reach	Large* Coniferous Pieces/ 1000 ft					Large Hardwood Pieces/ 1000 ft				
	1-2 ft	2-3 ft	3-4 ft	>4 ft	Total	1-2 ft	2-3 ft	3-4 ft	>4 ft	Total
1	0.3	0.7	0.3	0.1	1.3	1.9	0.3	0	0	2.1
2	1.8	0.9	1.4	0	4.1	2.0	0.2	0.2	0	2.5
3	3.4	3.4	3.4	2.2	12.4	1.1	0	0	0	1.1
4	6.8	3.4	2.3	0	12.6	2.3	0	0	0	2.3
5AB	4.5	5.4	2.9	2.2	15.0	1.1	0.3	0	0	1.3
5C	6.1	4.1	2.5	2.5	15.2	3.0	0	0	0.3	3.3
6	0.8	1.3	0.8	0.4	3.4	0.8	0.4	0	0	1.3
7	0	0	0	0	0	0	0	0	0	0
All	2.5	2.4	1.5	1.0	7.5	1.6	0.2	0.03	0.03	1.8

*** Large wood was at least 1 foot in diameter and at least 6 feet long.**

Baseflow

In 2001, the spring baseflow ranged between 1.5 and 5 cfs through the anadromous salmonid zone, providing higher water velocities and better feeding areas to promote important juvenile salmonid growth. In 1993, the streamflow in Reach 2 above the Old Woman's Creek confluence in May ranged between 4.20 and 4.90 cfs (**Nelson 1994**). Summer baseflow in 2001 was typical of small Central Coast streams, ranging between 0.5 and 1.5 cubic feet per second (cfs) in a gaining fashion from upstream of the anadromous salmonid zone (above Reach 7) to the water diversions in Reach 1 at approximately channel mile 0.3 (**Figure 16**). Summer baseflow in Gazos Creek upstream of the water diversions was similar to baseflow in smaller San Lorenzo River tributaries and the upper mainstem San Lorenzo, as well as upper Soquel Creek (**Figures 17 and 18**) (**Alley 2001a; 2001b**). Gazos baseflow was substantially higher than summer baseflows in West Fork Waddell or Scott Creek upstream of the Big Creek confluence (**J. Smith, personal communication**). During the 1993 CDFG study, the baseflow measurements downstream of the water diversion were lowest on 23 August 1993 at 0.25 cfs (**Nelson 1994**). Nelson (**1994**) noted that flow reduction in the lower portion of the stream coincided with pumping from the surface diversion and well field.

Riparian Canopy Closure

The riparian canopy closure was typical of small Central Coast streams and upper reaches of larger watersheds, with generally increasing stream shading in an upstream direction. Reach averages from limited frequency measurements ranged from 52% (Reach 1) to 85% (Reach 7) on the mainstem, with the South Fork near 75% (Reach 8) (**Figure 19**). In 2001, the overall mean canopy closure for all of the reaches combined was 65% (n=77). The optimal condition is to have the least canopy closure while maintaining water temperatures within the acceptable range for coho salmon and steelhead. In this regard, tree canopy in Gazos Creek was likely optimal. In streams that have less topographical shade or flow more north and south than Gazos, canopy closure would need to be greater to maintain cool enough water. The team botanist, Toni Danzig, measured tree canopy at 20 sites throughout the watershed, determining average canopy closure at each. These site averages varied from 19% to 90%, with an overall average of 66%. In addition, the east-west orientation of the stream through a steep canyon provided considerable topographic shading when the sun was in the southern sky. The zone of more frequent coho use (Reaches 5A-B to 6) was more shaded than downstream (**Figure 19**), with approximately 75% average canopy closure in 2001. By comparison, the upper reaches of Soquel Creek were similarly shaded with canopy closure between 70 and 90% (**Figure 20**) (**Alley 2001b**). Canopy closure over Gazos Creek was provided primarily by deciduous riparian forest (alder/willow/big leaf maple, coastal live oak) in Reaches 1 and 2, about half deciduous and half evergreen (conifer/bay laurel/tanoak) forest in Reach 3 and primarily conifer/bay laurel/tanoak in Reaches 4-7 (**Figure 19**). The South Fork was dominated by evergreen forest (Reach 8).

Water Temperature

Water temperatures were adequately cool for coho and steelhead juveniles in summer, 2001. Based on data from continuous water temperature monitoring by Balance Hydrologics, Inc. in 2001, minimum daily temperatures in Reach 1 were in the 13-14°C range during the summer, with maximum daily temperatures in the 16-18°C range. These temperatures were adequate for coho salmon and steelhead. During our survey work in the mainstem between 21 August and 3 September 2001, water temperature ranged between 57°F (13.9°C) and 62°F (16.7°C). The warmest water temperatures in mid-October were 57°F (13.9°C) in the mainstem and 54°F (12.2°C) in the South Fork. These were cooler temperatures than existed in much of the San Lorenzo and Soquel Creek watersheds (**Alley 2001a; 2001b**).

Sediment Impairment

In 2001, the streambed was heavily sedimented, especially in pools (45-80% of the streambed in Reaches 1-5C and the South Fork) and spawning glides (30-40% of the streambed) (**Tables 1-9; Figures 11 and 12**). Optimal percent fine sediment in pools of Central Coast streams would be 50% or less, though levels found in Gazos Creek were pretty typical of the region. As fine sediment is reduced in spawning gravel, survival of salmonid eggs and embryos is increased. Spawning glides with 25-35% fines is pretty typical of Central Coast streams, which are usually sediment impaired. Pools had highly embedded cobbles (45-55% except for 35% in the South Fork), as did fastwater habitat (40-45% except 25% in the South Fork) (**Figures 13 and 14**). The less fine sediment around larger cobbles the better the habitat quality. Larger cobbles do not offer cover for fish until they become less than 25% embedded in pools and fastwater. Less embedded cobbles in riffles offer greater interstitial space for aquatic insects to utilize. Optimal embeddedness would be in the range of 0-25% embeddedness. Embeddedness of 40-60% in pools and 35-45% in fastwater habitat (riffles and runs) are typical values for streams of the Central Coast. In 2001, spawning glides ranged from an average of 40% to 55% embeddedness per reach in 2001 compared to less embeddedness in 1993 (**Nelson 1994**) when 55% were embedded less than 25% and the remainder between 25 and 100%. Fastwater habitat in Gazos Creek was highly embedded and sediment impaired (**Figure 14**) (**Alley 2001a**). In Gazos Creek there were few cobbles greater than 4 inches in diameter, leading to very poor aquatic insect habitat when combined with high sediment loads and high embeddedness by fine sediment.

Habitat Potential in the Lagoon

The Gazos Creek estuary is generally small and shallow, offering no saltwater transition between the Creek and the ocean. A concern is that if too much streamflow is diverted in dry years, the sandbar may close prematurely to block smolt out-migration for coho and steelhead.

After sandbar closure and freshwater conversion, the lagoon may offer good habitat for juvenile steelhead, though no fish sampling has been done. However, only a relatively small and shallow lagoon (3 feet deep) is formed. An estimated 0.5 cfs streamflow would likely convert the lagoon to freshwater adequately over a two-week period, providing significant steelhead habitat so long as summer inflow is protected. An inflow of 0.1-0.2 cfs may be required to maintain the summer lagoon, based on experience from other coastal lagoons (Soquel, San Simeon and Santa Rosa lagoons). If tidal overwash occurs during the summer, more than 0.2 cfs would be beneficial to more quickly flush the saltwater out before lagoon temperatures increased too high for steelhead. Saltwater forms a layer on the lagoon bottom that heats up because it does not mix with the surface waters that are cooled by the air. The sandbar typically has been observed open in late summer in Gazos Creek (**Smith personal communication**). However, this extended period of open sandbar may result from artificial sandbar breaching evidenced by other sandbars and lagoons in the vicinity being in place while the sandbar at Gazos remains open. More detailed observations of the Gazos Creek mouth will better explain what occurs.

Characterization of Fish Habitat by Reach in 2001

Reach 1

1. Pool depth similar to other reaches and typical of non-bedrock dominated reaches of Central Coast streams (averaged mean of 1.2 feet and maximum of 1.8 feet; **Figure 9**).

2. Escape cover index higher than most reaches and greater than most tributary reaches of the San Lorenzo River (average of 0.260 linear feet/ feet of pool habitat; **Figure 10**).

3. More than 50% pool habitat (**Table 1**). Small coastal streams with close to 50% pool habitat are typical. Although nearly all of the coho and most of the steelhead juveniles are found in pools, higher proportions of pool habitat are not necessarily better because the aquatic insects upon which salmonids feed are produced in fastwater riffles and runs.

4. 26% of the reach habitat (54% of the pools) was pools scoured by woody material (often by small diameter hardwoods).

5. The number of pieces of large woody material per foot of pool habitat was less than other reaches (0.9 pieces/ 100 ft of pool habitat).

6. Pool complexity in terms of average linear feet of cover per pool was the highest of all reaches for woody material and rootwad scoured pools (**Tables 1-6**).

7. Six of 17 measured pools (36%) had 15 feet or more of escape cover, indicating some complexity.

8. Undercut banks below perched alders were common sources of escape cover, with the tree canopy dominated by deciduous trees.

9. Large woody debris was primarily hardwood with fewer redwoods than upstream reaches (**Figure 1**). Undercut banks below perched alders were common sources of escape cover, with the tree canopy being dominated almost exclusively by deciduous trees through most of the reach.

10. Winter and spring inputs of quickly mobilized fine sediment from Old Woman's Creek likely restrict YOY steelhead and coho production in Reach 1.

11. Reach 1 was negatively impacted by fine sediment as other reaches, with the highest of all reaches in percent fines in pools (**Figure 11**), high percent fines in spawning glides (**Figure 12**), heavily embedded substrate in pools and riffles (**Figures 13 and 14**).

12. There was a severe shortage of cobbles greater than 4 inches, making aquatic insect habitat very limited.

13. Smith has observed chronic covering of the streambed with a coating of fine silt due to sediment from Old Woman's Creek.

Smith's sampling (1992-2001) at established sites indicated that YOY steelhead densities were generally lower in Reach 1 than upstream reaches, while yearling densities were similar (**Smith 2001b**) (**Figure 22**). Juvenile coho were found in low densities at the upper of two sites in Reach 1 in 1995, 1996 and 1998, and higher densities in 2002 (**Smith 2002**). Smith hypothesized that poor substrate quality may be reducing YOY steelhead and coho below Old Woman's Creek by reducing food for rearing and/or by reducing spawning attempts or success at downstream sites. Smith has observed chronic turbid conditions downstream of Old Woman's Creek after even small storms compared to good water clarity upstream. Also, gullies entering the reach from the north side of Gazos Creek likely contribute to turbidity. The relatively good cover and pool depth provided sufficient habitat for yearling densities to be as high as other reaches. Sampling of coho by Smith indicated that Reach 1 had chronically low densities even in years of strong year classes (1993, 1996, 1999). During the survey in 2001, deep, complex pools were present in Reach 1 with the average number of linear feet of cover in woody debris pools at 14 feet and for rootwad pools at 17 feet (**Table 1**; highest of all the reaches). However, poor spawning habitat and less spawning attempts in this turbid, sediment-laden reach may result in under-utilization by coho salmon.

<u>**Reach 2**</u>

1. Pool depth similar but shallower to other reaches and typical of non-bedrock dominated reaches of Central Coast streams (averaged mean of 1.0 feet and maximum of 1.7 feet; **Figure 9**).

2. Escape cover index higher than most reaches and greater than most tributary reaches of the San Lorenzo River (cover index of 0.193 linear feet/ feet of pool habitat; **Figure 10**).

3. Pool habitat made up 44% of the reach (**Table 2**).

4. 17% of the reach habitat was pools scoured by woody material, the lowest of the non-bedrock dominated reaches.

5. 42% of the pools were scoured by woody material.

6. The number of pieces of large woody material per foot of pool habitat was more than in Reach 1 (1.5 pieces/ 100 ft of pool habitat), but less than the other wood-dominated reaches.

7. Large woody material had a higher proportion of conifers than Reach 1, with hardwoods still strongly represented (**Figure 2**).

8. Low number of cut logs and stumps observed.

9. Undercut banks below perched alders were common sources of escape cover, with the tree canopy still being dominated by deciduous trees.

10. Pool complexity in terms of average linear feet of cover per pool was less than in Reaches 1, 3 and 5c for woody debris and rootwad pools and similar to other wood and rootwad scoured reaches (**Tables 1-6**).

11. Five of 45 measured pools (11%) had 15 feet of escape cover or more, indicating some complexity.

12. Fine sediment was prominent in pools as is typical of Central Coast streams (averaging 50% of the substrate; **Figure 11**), with percent fines high in spawning glides (averaging 35%; **Figure 12**) and high embeddedness in pools and fastwater habitat (averaging 45%; **Figures 13 and 14**).

13. Cobbles greater than 4 inches in diameter were scarce, contributing to poor aquatic insect habitat.

Sampling by Smith in 2001 and earlier years (1996-2000) indicated that YOY and yearling steelhead were well represented in Reach 2 relative to other upstream reaches (**Figure 22**). Their densities were slightly greater than the mean for 10 sites on Gazos Creek in 2001 (**Smith 2001b**). Though juvenile coho were equally represented compared to other reaches in the strong years of 1996 (may have been supplemented by hatchery fry) and 2002 (**Smith 2002**), they have been absent at the traditional sampling site in other years, including the strong year of 1999.

<u>Reach 3</u>

1. Pool depth similar and deeper than other reaches except Reach 5C and typical of non-bedrock dominated reaches of Central Coast streams (averaged mean of 1.3 feet and maximum of 2.0 feet; **Figure 9**).

2. Escape cover index the highest of any reaches and greater than most tributary reaches of the San Lorenzo River (cover index of 0.277 linear feet/ feet of pool habitat; **Figure 10**).

3. Pool habitat made up 45% of the reach (**Table 3**).

4. 35% of the reach habitat was pools scoured by woody material, the lowest of the non-bedrock dominated reaches.

5. 82% of the pools were scoured by woody material.

6. The number of pieces of large woody material per foot of pool habitat was more than in Reaches 1, 2 and 4 (2.6 pieces/ 100 ft of pool habitat), but less than in Reaches 5A-B and 5C.

7. Large woody material was mostly from conifers with a third of them being cut (**Figure 3**).

8. Conifers became a significant portion of the tree canopy in Reach 3, creating from 25-80% of the canopy closure where estimates were made.

9. Undercut banks below perched alders declined substantially from lower reaches.

10. Pool complexity in terms of linear feet of cover per pool was more than any other reach except Reach 1 in the wood and rootwad scoured reaches (woody material pools with 11 feet / pool and rootwad pools with 10 feet/ pool; **Tables 1-6**).

11. Five of 23 pools (22%) had at least 15 feet of escape cover, indicating complexity.

12. Fine sediment was prominent in pools as in other reaches (averaging 45% of the substrate; **Figure 11**), with percent fines in spawning glides the highest of all the reaches (averaging 40%; **Figure 12**) and high embeddedness in pools and fastwater habitat (averaging 50 and 40%, respectively; **Figures 13 and 14**).

13. Cobbles greater than 4 inches in diameter were scarce, contributing to poor aquatic insect habitat.

Sampling by Smith in 2001 and earlier years at his traditional sites indicated that YOY steelhead were well represented in Reach 3 relative to sites in other reaches, with yearling densities being lower than sites in other reaches (**Figure 22**). Densities of both age classes were slightly less than the mean for 10 sites on Gazos Creek in 2001 (**Smith 2001b; 2002**). Therefore, higher densities of juvenile steelhead at Smith's sampling site did not express the higher quality habitat. Traditional sampling sites provide good indicators of trends in population size. However, fish densities at the sites may not represent average densities for the reaches they are located in. Though juvenile coho were present at the Reach 3 site in the one strong year, 1999, sites in reaches 5B, 5C and 6 had higher densities. Coho have been absent at the traditional sampling site in Reach 3 in other years except 2002 (**Smith 2002**).

<u>Reach 4</u>

1. Pool depth similar to other reaches and typical of non-bedrock dominated reaches of Central Coast streams (averaged mean of 1.2 feet and maximum of 1.9 feet; **Figure 9**).

2. Escape cover index was higher than most reaches and greater than most tributary reaches of the San Lorenzo River (cover index of 0.222 linear feet/ feet of pool habitat; **Figure 10**).

3. Pool habitat made up 52% of the reach (**Table 4**).

4. 24% of the reach habitat was pools scoured by woody material, the lowest of the non-bedrock dominated reaches.

5. 61% of the pools were scoured by woody material.

6. The number of pieces of large woody material per foot of pool habitat was less than adjacent reaches (2.0 pieces/ 100 ft of pool habitat).

7. Large woody material was dominated by conifers as would continue upstream (**Figure 4**).

8. Four of the 9 pieces (44%) of large woody material were cut.

9. The tree canopy was predominantly conifers, ranging between 50 and 85% of the canopy closure.

10. Pool complexity in terms of linear feet of cover per pool was similar to Reaches 2 and 5A-B, but less than in Reaches 1, 3 and 5c for woody debris in rootwad (**Tables 1-6**).

11. Two of 12 (17%) measured pools had 15 feet or more of escape cover, indicating some complexity.

12. Fine sediment was prominent in pools (averaging 45% in woody debris pools and 65% in rootwad pools; **Figure 11**), with percent fines high in spawning glides (averaging 35%; **Figure 12**) and high embeddedness in pools and fastwater habitat (averaging 55 and 45%; **Figures 13 and 14**).

13. Cobbles greater than 4 inches in diameter were scarce in pools and only present in a minority of fastwater habitats, contributing to poor aquatic insect habitat.

No fish sampling sites were located in the short Reach 4.

Reach 5A-B

1. Pool depth similar to other reaches and typical of non-bedrock dominated reaches of Central Coast streams (averaged mean of 1.2 feet and maximum of 1.8 feet; **Figure 9**).

2. Escape cover index was lower than the 4 lower reaches but still greater than most tributary reaches of the San Lorenzo River (cover index of 0.163 linear feet/ feet of pool habitat; **Figure 10**).

3. Pool habitat made up 47% of the reach (**Table 5**).

4. 30% of the reach habitat was pools scoured by woody material, the lowest of the non-bedrock dominated reaches.

5. 71% of the pools (60 of 84) were scoured by woody material.

6. The number of pieces of large woody material per foot of pool habitat was more than the 4 downstream reaches (2.9 pieces/ 100 ft of pool habitat), but less than in Reach 5C.

7. Cut redwood logs and stumps became important sources of woody debris in Reach 5A-B (34 of 117 large woody material; 29%). There were an additional 9 old redwood rootwads less than 6 feet long in the channel.

8. Conifers were the primary streamside vegetation, creating from 30-90% of the canopy closure where estimates were made.

9. Pool complexity in terms of linear feet of cover per pool was less than the adjacent reaches, but 10 of 54 measured pools (18%) had more than 15 feet of escape cover, indicating complexity in some pools.

10. Fine sediment was prominent in pools as in other reaches (averaging 45% of the substrate; **Figure 11**), with percent fines in spawning glides high (averaging 35%; **Figure 12**) and high embeddedness in pools and fastwater habitat (averaging 55 and 45%, respectively; **Figures 13 and 14**).

11. Cobbles greater than 4 inches in diameter were scarce in pools and many fastwater habitats, contributing to poor aquatic insect habitat.

Sampling by Smith in 2001 and earlier at his 3 sites in Reach 5A-B indicated that YOY steelhead were usually at greater densities than at sites in other reaches, with yearling densities being lower than sites in other reaches until 2001 (**Figure 22**). In 2001, sites in this reach had some of the highest steelhead YOY densities in Gazos Creek and yearling densities similar to other reaches. Densities of YOY's were more than the mean for 10 sites on Gazos Creek in 2001, while yearling densities were close to the average (**Smith 2001b**). Coho salmon have been present in this reach during the strong years, 1993, 1996, 1999 and 2002 (**Smith 2002**), but not in 1995 and 1998 when coho were scarce elsewhere. This reach is definitely within the typical coho zone of the creek, as the number of pieces of large woody material increased in this reach and the next compared to other reaches.

Reach 5C

1. Pool depth was greater than other reaches and typical of non-bedrock dominated reaches of Central Coast streams (averaged mean of 1.5 feet and maximum of 2.0 feet; **Figure 9**).

2. Escape cover index was similar to Reach 5A-B and lower than the 4 lower reaches but still greater than most tributary reaches of the San Lorenzo River (cover index of 0.156 linear feet/ feet of pool habitat; **Figure 10**).

3. Pool habitat made up 47% of the reach (same as Reach 5A-B) (**Table 6**).

4. 30% of the reach habitat was pools scoured by woody material, the lowest of the non-bedrock dominated reaches.

5. 74% of the pools (31of 42) were scoured by woody material.

6. The number of pieces of large woody material per foot of pool habitat was the highest of the reaches (3.5 pieces/ 100 ft of pool habitat).

7. Cut redwood logs and stumps were less important sources of woody debris in Reach 5C than 5A-B (11 of 73 large pieces of woody material; 15%).

8. Conifers were the primary streamside vegetation, creating from 50-90% of the canopy closure where estimates were made.

9. Pool complexity in terms of linear feet of cover per pool was higher than most reaches (averaging 10 feet per woody material and rootwad pool), with 1 of 9 measured pools (11%) having more than 15 feet of escape cover, indicating complexity in some pools.

10. Fine sediment was prominent in pools as in other reaches (averaging 70% of the substrate; **Figure 11**), with percent fines in spawning glides high (averaging 30%; **Figure 12**) and high embeddedness in pools and fastwater habitat (averaging 55 and 40%, respectively; **Figures 13 and 14**).

11. Cobbles greater than 4 inches in diameter were uncommon in pools. But, unlike downstream reaches, cobbles larger than 4 inches were common in fastwater habitat, contributing to better aquatic insect habitat than downstream. However, high embeddedness reduces insect productivity.

In 1999-2001, YOY densities at Site 5 in Reach 5C have been less than at Reach 5A-B (**Figure 21**), likely due to the greater tree canopy at Site 5. Yearling steelhead densities have been similar in Reaches 5C and 5A-B and somewhat lower than in Reaches 1 and 2 (**Figure 21**). Juvenile coho were present in Reach 5C in the strong years, 1999 and 2002, as well as in 1998, indicating that it is in the coho zone of Gazos Creek (**Smith 2002**).

Reach 6

1. Pool depth was similar to other reaches for mean pool depth, but shallower in maximum depth than most reaches and was shallower than typical for bedrock-dominated reaches of tributaries of the San Lorenzo River (Boulder and Bear creeks) (averaged mean of 1.2 feet and maximum of 1.7 feet; **Figure 9**).

2. Escape cover index was less than other downstream reaches and near the average for tributary reaches of the San Lorenzo River (cover index of 0.136 linear feet/ feet of pool habitat; **Figure 10**).

3. Pool habitat made up 46% of the reach (**Table 7**).

4. 6.6% of the reach habitat was pools scoured by woody material; lower than the 5 non-bedrock dominated reaches downstream.

5. Only 18% of the pools (4 of 22) were scoured by woody material. 68% of the pools (15 of 22) were bedrock scoured.

6. The number of pieces of large woody material per foot of pool habitat was lower than other mainstem reaches except Reach 1 and 7 (1.0 piece/ 100 ft of pool habitat).

7. Cut redwood logs and stumps were less important sources of woody material in Reach 6 compared to downstream reaches (2 of 11 large pieces of woody material; 18%). Big leaf maples and Douglas fir appeared prominently in large woody debris, unlike downstream.

8. Conifers were the primary streamside vegetation, creating from 70-85% of the canopy closure where estimates were made.

9. Pool complexity in terms of linear feet of cover per pool was less than downstream reaches, with 2 of 5 measured pools having 15 feet or more escape cover, indicating complexity in some pools.

10. Fine sediment was prominent in pools other than bedrock (averaging 35% of the substrate; **Figure 11**), with percent fines in spawning glides absent because they were bedrock and high embeddedness in pools and fastwater habitat (averaging 50 and 40%, respectively; **Figures 13 and 14**).

11. Cobbles greater than 4 inches in diameter were common in pools. Unlike downstream reaches, cobbles larger than 4 inches were common in fastwater habitat, contributing to better aquatic insect habitat than downstream. However, the high embeddedness reduces insect productivity.

Smith's sampling of a site in Reach 6 since 1998 indicated relatively good (sometimes above average) YOY steelhead production until 2001 and average yearling density compared to other reaches (**Figure 22**). The highest site density for juvenile coho in 1999 was at the Reach 6 site, indicating its use by this species in strong years.

Reach 7

1. Due to the mostly bedrock streambed, pool depth was less than downstream reaches and was shallower than typical for bedrock dominated reaches of tributaries of the San Lorenzo River (Boulder and Bear creeks) (averaged mean of 1.1 feet and maximum of 1.6 feet; **Figure 9**).

2. Escape cover index was less than other downstream reaches and less than the average for tributary reaches of the San Lorenzo River (cover index of 0.077 linear feet/ feet of pool habitat; **Figure 10**).

3. Pool habitat made up 44% of the reach (**Table 7**).

4. No large woody debris was present in the low flow channel of Reach 7.

5. 92% of the pools (11 of 12) were bedrock scoured.

6. Conifers were the primary streamside vegetation, creating from 75-100% of the canopy closure where estimates were made.

7. Pool complexity in terms of linear feet of cover per pool was absent.

8. Bedrock dominated pools with fine sediment present (averaging 20% of the substrate; **Figure 11**) and high embeddedness in pools and fastwater habitat (averaging 50 and 40%, respectively; **Figures 13 and 14**).

9. Cobbles greater than 4 inches in diameter were present in pools. Unlike downstream reaches, cobbles larger than 4 inches were common in fastwater habitat, contributing to better aquatic insect habitat than downstream. However, the high embeddedness reduces insect productivity.

Smith's sampling site at the very upstream end of Reach 6 in 1999 and 2002, consisting of a deep pool at the base of a bedrock chute had relatively high densities of YOY steelhead in 1999 and slightly above average densities in 2002 (**Smith 2002**). Yearling steelhead were at the highest density in the Creek in 1999 and 2002. (Alley considered this pool to be at the upper extent of Reach 6 during habitat typing analysis because adult salmonid access upstream would be more restricted, warranting a reach boundary.) No coho have been detected in this deep pool until 2002, indicating lack of access by coho adults and spawning upstream of the bedrock chute. No coho were detected upstream of this pool, in Reach 7, in 2002.

Reach 8- South Fork (Bear Gulch)

1. Pool depth was shallow and less than mainstem reaches for mean and maximum depth due to the small channel size (averaged mean depth of 0.7 feet and maximum depth of 1.1 feet; **Figure 9**).

2. Pools were shallower than typical non-bedrock dominated reaches of tributaries in the San Lorenzo River drainage.

3. Escape cover index was near the average for Gazos reaches and higher than the average for tributary reaches of the San Lorenzo River (cover index of 0.175 linear feet/ feet of pool habitat; **Figure 10**).

4. Pool habitat made up 31% of the reach (**Table 9**).

5. 13.7% of the reach habitat was pools scoured by woody material; lower than the 5 non-bedrock dominated reaches of the mainstem because of mostly riffle habitat (59%).

6. 50% of the pools (9 of 18) were scoured by woody material.

7. Conifers were the primary streamside vegetation, creating from 40-85% of the canopy closure. Big leaf maple, tanoak and alder were also present.

8. Pool complexity in terms of linear feet of cover per pool was less than most mainstem reaches due to the small pool size. The largest, most complex pool was immediately under and downstream of the first bridge.

9. Fine sediment was prominent in pools (averaging 55% of the substrate; **Figure 11**), with no spawning glides found and the least embeddedness in pools and fastwater habitat of any reaches (averaging 35 and 25%, respectively; **Figures 13 and 14**).

10. Cobbles greater than 4 inches in diameter were common in pools. Unlike downstream reaches, cobbles larger than 4 inches were common in fastwater habitat, contributing to better aquatic insect habitat in wet years than the mainstem.

The South Fork (Bear Gulch) was not sampled, though juvenile steelhead were observed throughout the anadromous reach in 2001, and resident trout were observed upstream of migrational barriers that began at 915 feet from the mouth.

<u>Old Woman's Creek</u>

Study of Old Woman's Creek was beyond the project scope. However, Nelson (**1994**) surveyed approximately 0.7 mile of the Creek to a culvert crossing that had been an absolute barrier to anadromy. This culvert has since blown out. The Creek was primarily flatwater habitat (runs, glides and step-runs) (70%), with riffles nearly absent (2%) and the remainder being very shallow pools (28%). Maximum depths in all pools included 3 pools 2- <3 feet, 28 pools 1- <2 feet and 17 pools with maximum depths less than 1 foot. Dominant substrate in pools was silt. Smith has identified Old Woman's Creek as a chronic sediment source with very limited value to the fishery, while degrading habitat values in Gazos Creek below. Several logjams functioned as sediment traps in 1993. Nearly all of the spawning glides were unconsolidated silt and sand in 1993. Rearing and spawning habitat was considered marginal, yet steelhead were present throughout the reach. Instream cover in pools was limited as undercut banks (36%), small woody debris (24%) and boulders (13%). Percent canopy closure was 91%.

Table 2. Mainstem Gazos Creek in Reach 1; Summary of Habitat Types and Habitat Characteristics in 2001, Located Downstream of the Old Woman's Creek Confluence. (Rosgen C4/5 Channel.)

Habitat Type	Units Measured # 2001	Total Length ft 2001	Avg Length ft 2001	Avg Width ft 2001	Avg Depth ft 2001	Avg Max. Depth ft 2001	Avg Embed-dedness 2001	Avg % Fines 2001	Avg Escape Cover 2001	Habitat Propor-tion 2001
LSL	42	1,982	47	12	1.2	1.8	50	80	14	26.2
LSR	29	1,518	52	11	1.1	1.7	55	85	17	20.1
LSBk	6	270	45	10	1.2	1.9	55	80	3	3.6
LSBo(art)	1	80	80	10	1.0	1.5	45	80	-	1.1
ALL POOLS	78	3,850	49	11	1.2	1.8	50	80	13.5	51.0
LGR	71	1,803	25	7	0.3	0.5	35	-	0.2	23.9
RUN	31	1,216	39	9	0.5	0.7	50	-	0.6	16.1
GLD	35	688	20	13	0.3	0.5	50	35	0.2	9.1

Total Units Surveyed- 215; Total Length Surveyed-7,557 ft (11,289 ft to Old Woman Creek Confluence)

lateral scour woody debris pool (LSL), lateral scour rootwad pool (LSR), lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), dammed pool (DPL), low gradient riffle (LGR), glide (GLD).

Table 3. Mainstem Gazos Creek in Reach 2; Summary of Habitat Types and Habitat Characteristics in 2001, Located Between Old Woman's Creek Confluence and Point Where Channel was Within Logjam Backwaters from Two 1998 Jams. (Rosgen C4 Channel.)

Habitat Type	Units Measured # 2001	Total Length ft 2001	Avg Length ft 2001	Avg Width ft 2001	Avg Depth ft 2001	Avg Max. Depth ft 2001	Avg Embed-dedness 2001	Avg % Fines 2001	Avg Escape Cover 2001	Habitat Propor-tion 2001
LSL	21	744	35	11	1.1	1.8	45	55	9	16.6
LSR	22	978	43	10	1.0	1.7	45	50	7	21.8
LSBk	6	229	38	9	1.1	1.9	30	50	3	5.1
LSBo(art)	1	41	41	11	1.0	1.6	-	20	11	0.9
ALL POOLS	50	1,951	39	10	1.0	1.7	45	50	7.1	44.4
LGR	50	1,446	29	7	0.2	0.4	45	-	1.0	32.3
RUN	16	474	30	7	0.4	0.6	45	-	0.8	10.6
GLD	28	566	20	10	0.25	0.4	40	35	0.9	12.6

Total Units Surveyed- 144; Total Length Surveyed- 4,478 ft.

lateral scour woody debris pool (LSL), lateral scour rootwad pool (LSR), lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), dammed pool (DPL), low gradient riffle (LGR), glide (GLD).

Table 4. Mainstem Gazos Creek in Reach 3; Summary of Habitat Types and Habitat Characteristics in 2001, Located From Beginning of 1998 Logjam Backwaters to Upper End of Backwater Area. (Rosgen B4c Channel.)

Habitat Type	Units Measured # 2001	Total Length ft 2001	Avg Length ft 2001	Avg Width ft 2001	Avg Depth ft 2001	Avg Max. Depth ft 2001	Avg Embed-dedness 2001	Avg % Fines 2001	Avg Escape Cover 2001	Habitat Propor-tion 2001
LSL	18	623	35	12	1.3	2.1	50	45	11	35.0
LSR	3	163	54	11	0.9	1.9	60	50	10	9.2
DPL	1	22	22	15	0.5	1.1	60	50	4	1.2
ALL POOLS	22	808	37	12	1.2	2.0	50	45	10.2	45.4
LGR	20	482	24	8	0.2	0.5	40	-	1.0	27.1
RUN	6	137	23	6	0.45	0.75	45	-	0	7.7
GLD	15	352	23	8.5	0.35	0.5	50	40	1.3	19.8

Total Units Surveyed- 63; Total Length Surveyed- 1,779 ft.

lateral scour woody debris pool (LSL), lateral scour rootwad pool (LSR), lateral scour bedrock pool (LSBk), dammed pool (DPL), low gradient riffle (LGR), glide (GLD).

Table 5. Mainstem Gazos Creek in Reach 4; Summary of Habitat Types and Habitat Characteristics in 2001, Located From Upper End of 1998 Logjam Backwaters to Beginning of Moderately Entrenched Rosgen B4c channel, 85 feet Downstream of Unnamed Southern Tributary. (Rosgen B4c Channel.)

Habitat Type	Units Measured # 2001	Total Length ft 2001	Avg Length ft 2001	Avg Width ft 2001	Avg Depth ft 2001	Avg Max. Depth ft 2001	Avg Embed-dedness 2001	Avg % Fines 2001	Avg Escape Cover 2001	Habitat Propor-tion 2001
LSL	8	211	26	14	1.4	2.2	55	45	9	24.1
LSR	4	137	46	12	0.9	1.5	65	65	5	15.6
LSBk	2	104	52	10	0.8	1.3	55	30	1.5	11.9
ALL POOLS	13	42	35	13	1.2	1.9	55	45	7.8	51.6
LGR	12	255	21	11	0.3	0.4	45	-	0.5	29.1
RUN	3	56	19	9	0.4	0.6	55	-	0.7	6.4
GLD	7	113	16	13	0.4	0.5	50	35	0	12.9

Total Units Surveyed- 36; Total Length Surveyed- 876 ft.

lateral scour woody debris pool (LSL), lateral scour rootwad pool (LSR), lateral scour bedrock pool (LSBk), low gradient riffle (LGR), glide (GLD).

Table 6. Mainstem Gazos Creek in Reach 5A-B; Summary of Habitat Types and Habitat Characteristics in 2001, Located From the Beginning of the Entrenched Rosgen B4c channel (85 feet Downstream of Unnamed Southern Tributary) to a Point Just Past the Former "Q" Logjam with 4 Redwood Stumps Remaining at the Road Turn-out. (Reach 5A was Rosgen B4c/F4 and Reach 5B was Rosgen B4c.)

Habitat Type	Units Measured # 2001	Total Length ft 2001	Avg Length ft 2001	Avg Width ft 2001	Avg Depth ft 2001	Avg Max. Depth ft 2001	Avg Embed-dedness 2001	Avg % Fines 2001	Avg Escape Cover 2001	Habitat Propor-tion 2001
LSL	60	2,438	41	12	1.1	1.8	55	45	7	32.0
LSR	8	390	49	12	1.2	1.9	60	55	8	5.1
LSBk	15	736	49	12	1.3	2.1	55	45	6	9.7
LSBo(art)	1	19	19	8	0.9	1.2	60	20	-	0.2
DPL	1	34	34	14	1.6	2.1	25	20	-	0.4

ALL POOLS	84	3,617	43	12	1.2	1.8	55	45	7.1	47.4
LGR	80	2,391	30	9	0.3	0.5	35	-	0.1	31.4
RUN	30	1,083	36	10	0.5	0.8	55	-	2.1	14.2
STP-RN	1	28	28	10	0.6	0.8	25	-	2	0.4
GLD	31	499	17	13	0.3	0.5	55	35	0	6.6

Total Units Surveyed- 227; Total Length Surveyed- 7,618 ft.

lateral scour woody debris pool (LSL), lateral scour rootwad pool (LSR), lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), dammed pool (DPL), low gradient riffle (LGR), step-run (STP-RN), glide (GLD).

Table 7. Mainstem Gazos Creek in Reach 5C; Summary of Habitat Types and Habitat Characteristics in 2001, Located From Just Upstream of the Former "Q" Logjam to the South Fork (Bear Gulch) Confluence.(Rosgen B4c Channel.)

Habitat Type	Units Measured # 2001	Total Length ft 2001	Avg Length ft 2001	Avg Width ft 2001	Avg Depth ft 2001	Avg Max. Depth ft 2001	Avg Embed-dedness 2001	Avg % Fines 2001	Avg Escape Cover 2001	Habitat Propor-tion 2001
LSL	31	1,190	38	14	1.5	1.9	55	60	10	30.2
LSR	6	261	44	14	1.5	2.2	50	80	10	6.6
LSBk	5	390	78	17	1.2	2.2	55	60	4	9.9
ALL POOLS	42	1,841	44	14.5	1.5	2.0	55	70	8.2	46.7
LGR	41	1,099	27	14	0.2	0.4	35	-	0.2	27.8
RUN	22	690	31	11	0.4	0.7	45	-	1.6	17.5
GLD	14	316	23	14	0.4	0.6	50	30	0	8.0

Total Units Surveyed- 119; Total Length Surveyed- 3,946 ft.

lateral scour woody debris pool (LSL), lateral scour rootwad pool (LSR), lateral scour bedrock pool (LSBk), low gradient riffle (LGR), glide (GLD).

Table 8. Mainstem Gazos Creek in Reach 6; Summary of Habitat Types and Habitat Characteristics in 2001, Located From the South Fork (Bear Gulch) Confluence to a Bedrock Chute Behind the Old Tennis Courts. (Rosgen B1 Channel.)

Habitat Type	Units Measured # 2001	Total Length ft 2001	Avg Length ft 2001	Avg Width ft 2001	Avg Depth ft 2001	Avg Max. Depth ft 2001	Avg Embed-dedness 2001	Avg % Fines 2001	Avg Escape Cover 2001	Habitat Propor-tion 2001
LSL	4	155	39	13	1.3	1.9	50	30	4	6.6
LSR	1	38	38	15	1.4	1.9	45	40	15	1.6
LSBk	15	825	55	14	1.2	1.7	50	30	4	35.0
LSBo	2	64	32	10	1.1	1.6	50	55	-	2.7
ALL POOLS	22	1,082	49	14	1.2	1.7	50	35	6	45.9
LGR	26	763	29	12	0.4	0.8	20	-	0.8	32.4
RUN	10	325	33	12	0.6	0.9	20	-	2	13.8
STP-RN	1	101	101	13	0.7	1.2	40	5	-	4.3
GLD	3	84	28	20	0.2	0.4	40	0	0	3.6

Total Units Surveyed- 62; Total Length Surveyed- 2,355 ft.

lateral scour woody debris pool (LSL), lateral scour rootwad pool (LSR), lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), dammed pool (DPL), low gradient riffle (LGR), step-run (STP-RN), glide (GLD).

Table 9. Mainstem Gazos Creek in Reach 7; Summary of Habitat Types and Habitat Characteristics in 2001, Located From the Bedrock Chute Behind the Old Tennis Courts to the Top of the Chute Just Upstream of the Middle Fork Confluence. (Rosgen A1 Channel.)

Habitat Type	Units Measured # 2001	Total Length ft 2001	Avg Length ft 2001	Avg Width ft 2001	Avg Depth ft 2001	Avg Max. Depth ft 2001	Avg Embed-dedness 2001	Avg % Fines 2001	Avg Escape Cover 2001	Habitat Propor-tion 2001

LSBk	11	394	36	14	1.2	1.7	55	20	3.5	40.2
LSBo	1	12	12	10	0.8	1.2	70	20	-	1.2
ALL POOLS	12	406	34	13	1.1	1.6	55	20	3.5	41.4
LGR	7	245	35	13	0.4	0.8	10	-	1.0	25.0
RUN	2	51	26	15	0.6	1.0	0	-	3	5.2
STP-RN	7	279	40	11	0.6	1.0	45	-	2	28.4

Total Units Surveyed- 28; Total Length Surveyed- 981 ft.

lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), dammed pool (DPL), step-run (STP-RN), low gradient riffle (LGR).

Table 10. South Fork (Bear Gulch) in Anadromous Reach 8; Summary of Habitat Types and Characteristics in 2001, Located From the South Fork (Bear Gulch) Confluence with Gazos Creek to a Bedrock Chute Adjacent to the Road.

Habitat Type	Units Measured # 2001	Total Length ft 2001	Avg Length ft 2001	Avg Width ft 2001	Avg Depth ft 2001	Avg Max. Depth ft 2001	Avg Embed-dedness 2001	Avg % Fines 2001	Avg Escape Cover 2001	Habitat Propor-tion 2001
LSL	9	125	14	6	0.7	1.1	35	55	3.5	13.7
LSR	3	56	19	7	0.7	1.1	35	60	2.7	6.1
LSBk	3	45	15	6	1.0	1.6	35	55	2.7	4.9
LSBo	3	54	18	4	0.3	0.5	20	35	0.5	5.9
ALL POOLS	18	280	16	5.5	0.7	1.1	35	55	2.7	30.6
LGR	23	538	23	4	0.1	0.3	25	-	0.6	58.8
RUN	8	97	12	4	0.2	0.3	30	-	0	10.6

Total Units Surveyed- 49; Total Length Surveyed- 915 ft.

lateral scour woody debris pool (LSL), lateral scour rootwad pool (LSR), lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), low gradient riffle (LGR).

Table 11. Gazos Creek Pools Sorted by Anadromous Reach and Maximum Depth, Fall 2001.

Reach	<1 ft	1-<1.5 ft	1.5-<2 ft	2-<2.5 ft	2.5-<3 ft	3-<3.5 ft	3.5-<4 ft	=>4 ft	Total # By Reach
1 (partial)	4	21	27	17	5	4	1	0	79
2	1	16	14	14	3	1	0	0	49
3	0	8	6	4	3	0	0	2	23
4	1	5	3	1	1	0	2	0	13
5A-B	2	19	32	20	5	5	1	0	84
5C	1	9	11	12	9	1	2	0	45
6	3	6	6	2	4	1	0	0	22
7	0	4	5	3	0	0	0	0	12
Total # by Depth	**12**	**88**	**104**	**73**	**30**	**12**	**6**	**2**	**327**
South Fork (Bear Gulch)	9	2	2	2	0	0	0	0	19

OTHER IMPORTANT HABITAT CONSIDERATIONS

Streambank Erosion

Most streambank erosion sites were active with vertical banks. Many were at meander cuts. A total of 1,884 feet of eroding streambank was measured. Streambank erosion in the lower 6 miles of mainstem Gazos Creek did not appear to be a substantial source of fine sediment to the stream. B-channels are typically relatively stable with limited bank erosion. The most important sediment sources were in Reach 5A-B, where two landslides and two eroding gullies were observed. Erosion in Reach 5A-B constituted 40% of the linear feet of eroding streambank. Refer to **Appendix A** for photo-documentation of erosion sites.

Reach 1 had 6 locations of streambank erosion, totaling 430 feet. Two were just upstream of logjams. Two were at the outside of bends, leaving active vertical banks and a fallen alder in one case. One slump was in a straight section and post-1998. The longest was 160 feet long but inactive with 6-12 inch DBH alders growing on its toe. Five of the six eroding streambanks were on the left bank (looking downstream). The streambank material was alluvial in all cases.

Reach 2 had 3 streambank erosion sites, totaling 239 feet. All three were at the outside of bends and had active alluvium. Two were associated with logjams.

No streambank erosion was noted in Reach 3.

Reach 4 had one erosion site, 70 feet long. A big leaf maple had sloughed off the slope in the 2000-2001 winter, and it was active alluvium.

Reach 5A-B had 12 instances of streambank erosion, totaling 780 feet. At most locations the streambank was vertical. The eroding material was alluvial in 10 of 12 sites, with 2 sites appearing to be sandstone in origin. There were two landslides. Two gullies were actively slumping in Class 3 drainages. Many trees were down in one. One erosion site was logjam-related. One vertical bank was in an actively slumping, narrow canyon. All but one site was actively eroding. At least 4 were initiated by the 1998 storms.

Reach 5C had 4 actively eroding banks, totaling 210 feet. All were meander cuts into alluvium at outside bends. Two were downslope from the road.

Reach 6 had one long, active slope failure. It was 155 feet long and was bedrock-shale in origin.

No erosion was observed in Reach 7.

<u>Water Quality</u>

The continuous water temperature recorder operated by Balance Hydrologics, Inc., in Reach 1 in summer of 2001 indicated that water was adequately cool for juvenile steelhead and coho salmon. From 19 June to 30 June 2001 the minimum water temperature was 13.0°C and the maximum was 17.3°C. For July the minimum and maximum water temperatures were 13.4°C and 17.7°C, respectively. For August they were 13.0°C and 17.5°C, respectively. For September they were 11.9°C and 15.8°C, respectively.

The relationship between water temperature and metabolic rate (measured as oxygen consumption) is basic to fish physiology and important in understanding fish distribution and ecology. Fish being ectotherms (cold-blooded), their body temperatures increase along with metabolic rate as water temperature increases. At higher temperatures, steelhead oxygen requirements and food demands increase, and steelhead are forced to fastwater habitat or other sources of abundant food. References that indicate that oxygen consumption by fishes increases with water temperature include Fry (**1947**), Beamish (**1964**) and Beamish (**1970**). Many fisheries textbooks refer to this relationship. An example is **<u>The Chemical Biology of Fishes</u>** by Malcolm Love (**1970**). The positive relationship between water temperature and metabolic rate in fishes leads to higher oxygen requirements as water temperature increases (**Nikolsky 1963**).

<u>Water Temperature Considerations - Coho Salmon in Gazos Creek</u>

There is an interdependence between water temperature, food supply and growth rate of juvenile salmonids. As water temperature increases, fish metabolic rate and food requirements also increase. However, if food aboundance greatly increases in some situations where water temperature is warmer, growth rate can be greater under warmer conditions, such as in a warm lagoon, such as Soquel Creek Lagoon, or lower mainstems of larger drainages with relatively high summer baseflow, such as the San Lorenzo River, Santa Rosa Creek and Soquel Creek (Alley 2001a; 2001c; 2002; 2003a). Food is also digested faster at higher temperatures, promoting faster food processing and growth if more food is available. However, each fish species has its thermal limits. Coho can potentially tolerate temperatures nearly as high as steelhead, but usually are found at much cooler temperatures. In Washington, stocked coho were found to do well in streams where temperatures exceeded 24.5ºC for more than 100 hours and reached 29.5ºC (**Bisson et al. 1988**). However, those were very productive sites, and other species (including steelhead) were scarce. The warm lagoon at Waddell Creek apparently failed to support coho in 1996, even though it was productive, and coho were present immediately upstream of the lagoon. Coho might not have been able to compete with steelhead in this warm, large pool situation when the water temperature exceeded 20ºC. In smaller and/or cooler pools, coho tended to successfully exclude young-of-the-year steelhead in Waddell and Scott creeks (**Smith unpublished**). However, juvenile steelhead were not excluded by coho from Gazos Creek pools in 2002 (**Smith 2002**), perhaps because of its higher baseflow and faster velocities entering pools than in Waddell and Scott creeks. This would allow for more spatial segregation of the two species with the steelhead feeding more at the head of pools.

According to Moyle (**2002**), juvenile coho prefer and are assumed to grow best at temperatures of 12-14ºC (53-57ºF). In the Mattole River system (northern California in southern Humboldt County) with generally sandy substrate similar to Gazos Creek, coho were found only in tributaries where the summer maximum weekly average water temperatures were 16.7ºC (62ºF) or less and the maximum weekly maximum temperatures were 18.0ºC (64ºF) or less (**Welsh et al. 2001**). These thermal conditions were met in Gazos Creek in 2001. In Scott and Waddell creeks in Santa Cruz County, coho have been found at warmer sites than those in the Mattole River, but only where pools were very productive (small pools, abundant algae, extensive, productive riffles upstream of the pools, etc.) (**Smith pers. communication**).

<u>Water Temperature Considerations- Steelhead in Gazos Creek</u>

According to Moyle (**2002**), Baltz et al. (**1987**) reported that optimal temperatures in Sierran streams for growth of resident rainbow trout (same species as steelhead) to be around 15-18ºC, when available. He added, "However, many factors affect choice of temperatures by trout (if they have a choice), including the availability of food." Though steelhead are found at warmer water temperatures than coho, the cooler water quality requirements for coho salmon should take precedence in Gazos Creek over water temperature considerations of steelhead.

In Central Coast salmonid streams, water temperature at which growth rate is maximized is primarily a food issue and not a physiological tolerance issue. Higher temperatures, especially above 21°C (70ºC), increase food demands and restrict the steelhead to faster habitats for feeding. But compensatory increases in food supply may allow young-of-the-year steelhead to reach smolt size after one growing season in warmer steelhead streams, such as Uvas Creek in the Pajaro River system (**Smith 1982; Smith and Li 1983**). The potentially negative impact of tree removal and elevated stream temperature in upper watershed reaches is two-fold. These reaches typically have very low summer baseflow and may heat up substantially from tree removal without the compensatory increase in food availability, particularly with the low insect drift rate associated with low summer baseflow. Secondly, diminished water quality will occur if what would naturally be heavily shaded, cool tributaries and upper mainstem reaches that provide cool water to downstream reaches become warm from tree canopy removal, then the lower watershed may become even warmer without compensatory food increases. According to Moyle (**2002**), water temperatures of 24-27°C are invariably lethal to trout, even when acclimation temperatures are high, except for very short exposures. But this is rarely, if ever reached in streams along the Central Coast. Even so, warmer temperatures could result in slow growth or starvation in steelhead if food supply becomes limited. The temperature range between optimal water temperature and the lethal limit may result in slower growth rate unless food supply also increases significantly.

Oxygen Considerations- Steelhead and Coho Salmon

Steelhead can likely survive oxygen levels in the cooler, early morning as low as 2 mg/l. However, the Regional Water Quality Control Board has established 7 mg/l as the dissolved oxygen objective for cold-water habitat in the San Francisco Bay Basin, because they believe that fish activity and survival is reduced at lower oxygen levels. This goal is easily met in flowing stream habitat where riffles recharge oxygen, but may not be in the lagoon under conditions in which saltwater has been trapped by sandbar closure without sufficient lagoon inflow. Artificial sandbar breaching after the initial sandbar formation has been shown to cause both temperature and dissolved oxygen problems (**Smith 1990**).

Local field data are lacking for establishing the minimum oxygen requirements for coho salmon juveniles. However, it is highly likely that starvation resulting from warm water temperature would become limiting to coho long before low oxygen levels would become a factor. It is probable that oxygen levels in flowing, unpolluted streams and riverine habitat would be ample for coho salmon, as is the case for steelhead. Saline lagoon conditions may reduce oxygen levels in deeper portions of the water column below the tolerance for coho, as with steelhead.

Streamflow

Data collected by the Coastal Watershed Council indicated that flows in late spring of 2001 ranged between 1.8 and 4.7 cubic feet per second (cfs) in a gaining fashion from above Reach 7 downstream to the boundary between Reaches 1 and 2 (**Figure 16**). The stream also appeared to be gaining in late summer, with streamflow increasing from 0.7 cfs above Reach 7 to 1.3 cfs just above the diversions in lower Reach 1 (**Figure 16**), although the uppermost streamflow was measured 2 weeks after the lowermost one. During the 1993 CDFG study, the baseflow measurements downstream of the water diversion were lowest on 23 August 1993 at 0.25 cfs (**Nelson 1994**). Nelson (**1994**) noted that flow reduction in the lower portion of the stream coincided with pumping from the surface diversion and well field.

Late summer baseflows in Gazos Creek were similar to those in intermediate sized tributaries of the San Lorenzo River in fall, such as Branciforte, Bean and Boulder creeks, and the upper mainstem below Kings Creek (**Figure 17**). Gazos baseflow was decidedly greater than other tributaries, such as Bear, Carbonera and Kings creeks. Gazos baseflows in late summer were somewhat lower than the Soquel Creek mainstem and similar to those in the East and West Branches (**Figure 18**).

HABITAT CHANGES BETWEEN 1993 AND 2001

Habitat typing of the lower 6.5 miles (34,219 feet) of Gazos Creek by CDFG in May and June 1993 (streamflow of 3-4 cfs) offered comparative data (**Nelson 1994**), although 2001 habitat typing was done in fall when streamflow was at a minimum. Comparisons should be made with caution because of individual differences in data collection between biologists, particularly when comparing habitat proportions.

General Comparisons. A higher proportion of habitat was pools in 2001 than 1993, and pools were longer. Woody material appeared to play a somewhat more important role in pool formation in 2001 than 1993. The El Nino winter of 1997-98 had brought considerable wood into the channel, and the County had cut up many of the jams. This cut wood had redistributed by 2001. In 2001 there was a slight shift toward shallower pools compared to 1993. Compared to 1993, there were more than 5 times as many glides identified in 2001, with 118 shorter glides detected compared to 18 longer glides observed in 1993. There was a higher proportion of riffle habitat in 2001 compared to 1993. Gazos Creek appeared somewhat less shaded in 2001 (65%) compared to 1993 (72%). Woody material provided a higher proportion of the escape cover in 2001 (57%) compared to 1993 (34%).

Proportion of Pool Habitat. A higher proportion of habitat was pools in 2001 than 1993, and pools were longer. At the higher 1993 streamflow, 38% of the habitat was classified as pools, averaging 38 feet in length. In 2001 between 41% and 51% of the habitat per reach were pools, with 47% of the mainstem being pool habitat (327 pools) of the 29,590 feet habitat typed. Pools averaged 43 feet in length in 2001. Therefore, there was a 9% increase in the proportion of pools from 1993 to 2001, although the difference may have been due to variation in data collection and/or the lower streamflow in 2001.

Role of Woody Material in Pool Formation. Woody material appeared to play a somewhat more important role in pool formation in 2001 than 1993. In 1993, 42% of the pool habitat (41% of the pools) was scoured by woody material and 32% of the pool habitat (33% of the pools) was scoured by rootwads. In 2001, 53% of the pool habitat (56% of the pools) was formed by scour from woody material. Perhaps the El Niño storms of 1997-98 brought more wood into the stream to scour more pools despite cutting up of logjams in 1998. Then too in 1993, 13% of the pools (45) were categorized either as mid-channel, step, corner or plunge pools without identifying the cause of scour, unlike in 2001 when scour was identified for every pool. Therefore, the different methods could explain less wood scouring in 1993. In 2001, 26%, of the pool habitat (22% of the pools) was scoured by rootwads compared to 32% in 1993.

Shift in Pool Depth. In 2001 there was a slight shift toward shallower pools compared to 1993. In 2001, pool depths per reach averaged 1-1.2 feet for mean depth and 1.7-2.0 feet for maximum depth. In 2001, data on maximum pool depth showed 59% (192) of the 327 pools were 1- <2 feet, 32% (103) were 2- <3 feet, 5.5% (18) were 3-<4 feet, 1% (2) was greater than 4 feet and 4% (12) were less than 1 foot maximum depth (Table 10). The 1993 data for maximum pool depth showed 52% (178) of the 341 pools were 1- <2 feet, 41% (139) were 2- <3 feet, 5.0% (17) were 3-<4 feet, 1% (2) was greater than 4 feet and 1% (4) were less than 1 foot maximum depth. However, some of the shallowest pools in 2001 may have been identified as runs in 1993 with more streamflow. Also, with lower streamflow in 2001, pools may have been slightly shallower. In 2001 there was a 3% higher proportion in the less than 1 foot range, a 7% higher proportion in the 1- <2 foot range, with a 9% smaller proportion in the 2- <3 feet range. The proportion of pools greater than 3 feet maximum depth was similar between 1993 and 2001.

Woody Material as Escape Cover. Woody material provided a higher proportion of the escape cover in 2001 compared to 1993. It provided most of the escape cover in mainstem pools in 2001. The percentage of cover provided by woody material in 2001 in Reach 1 was 40%; in Reach 2 was 45%; in Reach 3 was 84%; in Reach 4 was 53%; in Reach 5A-B was 67%; in Reach 5C was 57%; in Reach 6 was 0%; and in Reach 7 was 0%. Overall, 57% of the escape cover in 2001 was from woody material. In 1993 with different methods, 34% of the escape cover in pools was provided by woody material. In 2001, 25% of the escape cover in pools came from undercut banks compared to 31% in 1993.

Occurrence of Significant Wood Clusters (Logjams). In 2001, 11 logjams were detected that spanned the channel (**M. Leicester, pers. communication**) compared to 28 logjams (not defined) identified in 1993 (**Nelson 1994**). Leicester noted 11 more logjams that covered either the right or left side of the channel only. None of the logjams were considered passage problems in 2001, while 7 were considered potential passage problems in 1993. In 2001 there were 31 pools in Gazos Creek where at least 3 pieces of large woody material accumulated together in the low flow channel.

Incidence of Glides. Compared to 1993, 7 times as many glides were identified in 2001, with 133 glides detected in 2001 (8.8% of the habitat surveyed, averaging 20 feet in length). Steelhead and coho salmon usually spawn in glide habitat that possesses adequately sized spawning substrate and a narrowing, steep riffle immediately downstream. Only 18 glides were identified in 1993, representing 3.3% of the habitat and averaging 63 feet in length. However, Nelson may have included glide habitat at the tails of pools as pool habitat, whereas we distinguished between the two. Difference between 1993 and 2001 may have occurred because some habitats identified as runs in 1993 with more streamflow may have been identified as glides later in the season when 2001 data were collected. However, in 1993 there were 148 runs, with nearly as many identified in 2001 (120) in less distance surveyed. Another explanation for the increased number of glides in 2001 may be that stream sedimentation has caused the pool tail crests to be more gradual, creating more instances of glide habitat at the tails of pools than was present in

1993. Gazos Creek had more glide habitat than we typically observed in the San Lorenzo and Soquel watersheds.

Proportion of Riffle Habitat. There was a higher proportion of riffle habitat in 2001 compared to 1993. Riffle habitat made up between 24% and 32% per reach in 2001 as compared to an overall average of 13% in 1993. Some of the runs and step runs in 1993 could have been identified as riffles in 2001 with the reduced baseflow later in the season. Only 9 step runs were identified in 2001 compared to 23 in 1993.

Tree Canopy Closure. Gazos Creek appeared somewhat less shaded in 2001 compared to 1993. In 2001, the overall mean canopy closure for all of the reaches combined was 65% (n=77). In 1993 the overall mean canopy closure for all of the reaches was 72% (**Nelson 1994**). These were small differences considering the probable differences in sampling methods.

EXTENT OF ANADROMY

Summary of Findings

The extent of anadromy for steelhead on the mainstem was probably not above the chute (BN-1) just upstream of the Middle Fork confluence on the North Fork at channel mile 6.7 beginning at Highway 1 (**Figure 3 of the Gazos Creek Watershed Enhancement Plan**). Refer to **Appendix A** for photo-documentation of passage impediments and barriers. See below for better descriptions of locations of passage impediments. Adult steelhead may migrate beyond BN-1 when conditions are optimal, with the absolute barrier to anadromy being the large chute (BN-2) at approximately 6.9 miles from Highway 1, 1,300 feet upstream of BN-1. Salmonids observed by Coastal Watershed staff approximately 1.5 miles upstream were likely resident rainbow trout originating from planting or the rare occasion when adult steelhead were able to negotiate the barrier before its present conformation.

The absolute barrier to coho salmon adult migration appeared to be at channel mile 6.5 from Highway 1, at the beginning of Reach 7 (around the bend, 1,775 feet past the Gazos Creek Road Bridge crossing and adjacent to where the Mountain Camp tennis courts once stood), based on juvenile sampling performed by Jerry Smith through the years. The chute (which we will term the “Coho Chute”) was 90 feet long, 30 feet wide at its base and 20 feet wide at the top with coho in the pool immediately downstream of it in 2002. A shorter chute existed 360 feet downstream of the Coho Chute that was apparently passable to coho, which was 46 feet long and 18 feet wide Another wide chute (which we will term the “South Fork Chute”) existed 160 feet downstream of the South Fork (Bear Gulch) confluence at channel mile 6.0. It was 25-40 feet wide and 58 feet long, possessing a few scour holes 4-5 feet in diameter. South Fork Chute may be a significant salmonid passage impediment during drought due to its width, and may block access to approximately 0.44 miles of habitat in the mainstem plus 0.17 miles of habitat in the South Fork that exist upstream before other bedrock chutes are encountered.

The Middle Fork is inaccessible to anadromous salmonids due to a 20-foot bedrock falls at its mouth. The South Fork (Bear Gulch) had a short reach without passage impediments to a chute at channel mile 0.17 (BN-1). A complete barrier to spawning migration was observed at a logjam (BN-5) situated at the confluence of an unnamed tributary, 0.3 miles from the mouth.

North Fork Passage Impediments

Natural Barrier 1 (BN-1)

Immediately upstream of the Middle Fork confluence was situated a bedrock chute that was likely an upstream passage impediment in most years. The GPS reading at the chute was N37º11.954; W122º17.542. This chute was the upper extent of Reach 7. Its dimensions were 33 feet width at the base and 20 feet width at the top, with an 8-foot drop over a length of 44 feet. BN-1 was likely a passage impediment at most streamflows and may be a velocity barrier when depth is sufficient for passage.

Natural Barrier 2 (BN-2)

At a distance of 1,304 feet upstream from BN-1 was a second bedrock chute (BN-2), steeper than BN-1. The streambed was completely bedrock between BN-1 and BN-2 with virtually no rearing habitat. The GPS reading at the chute was N37º12.137; W122º17.477. Large woody debris accumulated on the left bank. The chute represented an estimated 18 feet drop over 143 feet in length. The steepest gradient was the 12-foot drop at the bottom of the chute, where the width was 20 feet at the base and 40 feet at the top over 62 feet in length. Then the gradient reduced for the remaining 81 feet of chute length, with another 6 feet of elevation change and a width of 25 feet at the top. Water depth averaged between 0.1 and 0.2 feet on the day of observation (10/13/2001), with a maximum of 0.4 feet. This chute was judged an absolute passage barrier to adult salmonids. When water depth was sufficient for passage, the chute was undoubtedly a velocity barrier. There were no resting areas over the entire extent of the chute.

Natural Barrier 3 (BN-3)

At a distance of 1,994 feet upstream from BN-1 began a third bedrock chute (BN-3). Between BN-2 and BN-3 there was a 75-foot length of flat bedrock channel (1,650-1,725 feet from BN-1) that was 26 feet wide with a depth of only 0.1-0.2 feet. This section may prove an impediment to passage during drought conditions. BN-3 represented a 16-foot drop in elevation over a distance of 116 feet. It was 42 feet wide at its base and 24 feet wide at the top. No GPS reading was possible.

Natural Barrier 4 (BN-4)

At a distance of 2,430 feet upstream from BN-1 was situated a fourth bedrock chute (BN-4). It represented a 5-foot drop in elevation over a distance of 75 feet. The GPS reading at the location was N37º12.279; W122º17.466. BN-4 was 28 feet wide at its base and 20 feet wide at the top. There was no jump pool and the depth was 0.1-0.2 feet on 10/13/2001. This barrier was likely a passage impediment under most streamflows less than bankfull.

Natural Barrier 5 (BN-5)

At a distance of 2,915 feet upstream from BN-1 was a bedrock shelf, 55 feet wide with a 4- foot vertical drop (BN-5) and no jump pool. The GPS reading at the location was N37º12.325; W122º17.474. Water depth over the shelf was 0.1 feet on 10/13/2001. This shelf was likely a passage impediment except during stormflows approaching bankfull.

Natural Barrier 6 (BN-6)

At a distance of 3,350 feet upstream of BN-1 was another bedrock chute (BN-6) similar to BN-1. No GPS reading was possible. The chute represented an 8-foot drop over a distance of 36 feet. It was 22 feet wide at the top. Water depth was 0.1-0.2 feet on 10/13/2001. BN-6 was a passage impediment under most streamflows and could be a velocity barrier when depth was sufficient for passage.

Middle Fork Passage Impediment

Natural Barrier 1 (BN-1)

At the confluence with the North Fork was a two-step bedrock falls representing a 20-foot drop in elevation. This was a complete barrier to salmonid spawning migration.

South Fork Passage Impediments

Natural Barrier 1 (BN-1)

At a distance of 915 feet from the mouth was situated a bedrock chute (BN-1) observable from the road that paralleled the stream. Refer to **Appendix A** for photo-documentation of salmonid passage impediments/ barriers. The chute was upstream of the first bridge crossing. Its GPS location was N37º11.506; W122º17.641. The lower 16 feet in length represented a 6-foot drop in elevation, with a width of 32 feet at its base and 10 feet width after 16 feet. The chute continued upstream another 16 feet with a 3-foot wide notch. Juvenile steelhead were observed upstream of BN-1, with it being a passage impediment at some flows. After BN-1 were 172 feet of stream with bedrock bottom.

Natural Barrier 2 (BN-2)

At a distance of 172 feet upstream from BN-1 was situated a logjam barrier (BN-2) that was 10 feet wide requiring a 5-foot jump without a jump pool. Old growth redwood pieces caused the jam. Juvenile steelhead were observed above this passage impediment.

Natural Barrier 3 (BN-3)

At a distance of 285 feet upstream from BN-2 was another logjam barrier (BN-3). No GPS reading was possible. BN-3 was 15 feet wide and 7 feet high without a jump pool. A slope failure existed on the left bank that may have initiated the jam. This was a more formidable impediment than BN-2 and may be impassable at most streamflows. However, a larger salmonid, likely a resident trout was observed upstream at the base of the next passage impediment.

Natural Barrier 4 (BN-4)

At a distance of 210 feet upstream from BN-3 was a combination bedrock chute/ logjam barrier (BN-4). No GPS reading was possible. The bedrock chute that skirted the logjam was 8 feet wide and 7 feet high with no jump pool. The bedrock chute was 18 feet in total length and represented a significant velocity barrier when flows became sufficient to provide adequate depth for passage.

Natural Barrier 5 (BN-5)

Just 30 feet upstream of BN-4 and 697 feet beyond BN-1 (1,612 feet from the mouth) was a sizeable logjam barrier (BN-5). No GPS reading was possible. The BN-5 jam created a 9-foot drop and was likely a complete salmonid passage barrier at flows that did not create a velocity barrier to migrating salmonids. A dry tributary from the east entered in the vicinity of this large debris accumulation. The streambed was dry for 140 feet upstream due to the elevation drop. Another barrier was reported a short distance upstream by Maya Conrad (Coastal Watershed Council, **personal communication**) that represented approximately a 15-foot drop.

Old Woman's Creek Passage Impediments

Nelson (**1994**) had reported an impassable road culvert at channel mile 0.7 (BM-1) and had assessed habitat to that point. However, this barrier apparently blew out during the El Niño stormflows of 1997-98. Survey of the Creek was beyond the scope of this current contract and deemed unnecessary because of the Creek's assumed limited accessibility to steelhead, badly degraded habitat conditions and extremely limited fishery value. Future survey of the creek may adequately assess the extent of anadromy.

FACTORS THAT LIMIT SALMONID POPULATIONS

1. Barriers/ impediments to adult spawning migration.

2. Poor spawning substrate (too fine and too sediment-laden) that allows easy scour of spawning redds by later storms and that causes poor egg survival due to poor circulation of water through the gravels to supply oxygen.

3. Shortage of overwintering shelter for juveniles, especially newly hatched coho.

4. Low spring baseflow limiting the juvenile salmonid food supply and subsequent growth in the spring/early summer.

5. Loss of habitat complexity, escape cover and juvenile salmonid survival, particularly through reduced recruitment and retention of large woody material.

6. Barriers/impediments to smolt out-migration – particularly due to early sandbar closure caused by low streamflow in dry years or from excessive water diversion.

7. Reduced lagoon habitat area and degraded conditions (including poor water quality) particularly from low summer inflow and unseasonal sandbar breaching.

GAZOS CREEK ASSESSMENT AND ENHANCEMENT CONSIDERATIONS

Introduction

Any reduction in streamflow during the spring growing season and the dry summer and fall months of the year will reduce steelhead and coho salmon rearing habitat. Reduced streamflow results in reduced aquatic insect populations, reduced insect drift rate and reduced food supply for fish that feed on these drifting insects (both adult insects that drop in and larval insects that are produced in fastwater habitat).

Reduced streamflow results in higher water temperature, which increases metabolic demand for food and reduces fish growth and the size of juvenile salmonids, which is so important to ocean survival. Reduced streamflow reduces fish rearing habitat by reducing surface water turbulence and water depth in fastwater feeding areas (heads of pools, riffles and runs).

While there are no dams currently on Gazos Creek, future dams should be avoided. Any abutments to future seasonal dams or future dams for off-stream storage will potentially create barriers to upstream salmonid spawning migration and cause inundation of important fastwater feeding areas. If summer impoundments were created in highly shaded reaches common to Gazos Creek, food may not be sufficiently abundant to provide much summer rearing habitat for salmonids. Impoundments trap sediment that is typically released prior to winter stormflow, thus potentially causing sedimentation of habitat downstream. If water is released too quickly from seasonal impoundments, fish may be displaced or stranded at the stream margin, leading to mortality.

Riparian trees provide stream shading, which is very important to maintaining cool water temperatures for salmonids during the summer low-flow period. These trees also protect streambanks from erosion that would allow sedimentation of stream channels. Sedimentation reduces fish habitat and degrades spawning habitat. Efforts to reduce landsliding and erosion in the watershed will diminish stream sedimentation and increase habitat quality for coho salmon and steelhead in Gazos Creek.

Instream woody material, particularly large wood, causes scour that promotes pool formation and provides structural complexity and escape cover for salmonids. This pool habitat is critically important to coho salmon and steelhead in summer. Wood clusters provide overwintering shelter in backwaters, as well, to allow juvenile salmonids to survive winter stormflows. Removal of instream wood may result in fish mortality. However, large wood clusters may cause substantial streambank erosion and threaten roads. Therefore, partial removal of some instream wood may be necessary. In these cases, some wood should be retained to provide scour objects and escape cover.

Road construction on unstable slopes may greatly increase erosion and sedimentation, resulting in degraded spawning and rearing habitat for steelhead and coho salmon. Brown (**1991**) stated that the mass soil movement in forest watersheds is often triggered by road construction. He stated that one landslide or slump can place several times more sediment into a stream than is normally carried during a year. Roads made by cut and fill operations on slopes create roadbeds of potentially unstable fill material. These roads may change drainage patterns and sometimes focus runoff onto unstable slopes below, especially if the roads are not out-sloped.

The existing pond at Mountain Camp has been a refuge for non-native fishes (largemouth bass and green sunfish). These non-native fishes are predatory upon California red-legged frogs using the pond and juvenile salmonids if the non-natives spill into Gazos Creek or expand out from the pond to stream habitat. Jerry Smith has captured green sunfish in Gazos Creek (**Smith personal communication**). The allowance of fishing in the pond would increase the likelihood of illegal fishing in the nearby creek. Any summer diversion of water from the creek to maintain this off-stream pond will reduce summer rearing habitat for steelhead in Gazos Creek, to some degree. However, winter stream diversion to fill the pond and minimal summer diversion to maintain the pond during the dry season will likely have minimal impact on salmonids in Gazos Creek, while providing significant breeding and rearing habitat for California red-legged frogs once exotic species are removed.

Benefits of Properly Functioning Riparian Zones

There is a growing body of evidence that buffers along streams are necessary to protect aquatic ecosystems from potential disruption and degradation. The purpose of riparian buffer strips is to allow natural interactions between riparian and aquatic systems to be sustained so that appropriate instream ecosystems, sediment regimes and channel forms can be maintained. According to Reid and Hilton (**1998**), riparian zones are important to adjacent instream ecosystems because the strongly control the availability of food, distribution of predators, form of channels and distribution of temperatures (**Murphy and Hall 1981, Naiman and Sedell 1979, Theurer and others 1985, Zimmerman and others 1967**). Reid and Hilton (**1998**) enumerated specific roles of riparian zones in relation to the instream environment as follows:

- Maintenance of the aquatic food web through provision of leaves, branches and insects

- Maintenance of appropriate levels of predation and competition through support of appropriate riparian ecosystems

- Maintenance of water quality through filtering of sediment, chemicals and nutrients from upslope sources

- Maintenance of an appropriate water temperature regime through provision of shade and regulation of air temperature and humidity

- Maintenance of bank stability through provision of root cohesion on banks and floodplains

- Maintenance of channel form and instream habitat through provision of woody debris and restriction of sediment input

- Moderation of downstream flood peaks through temporary upstream storage of water

- Maintenance of downstream channel form and instream habitat through maintenance of an appropriate sediment regime

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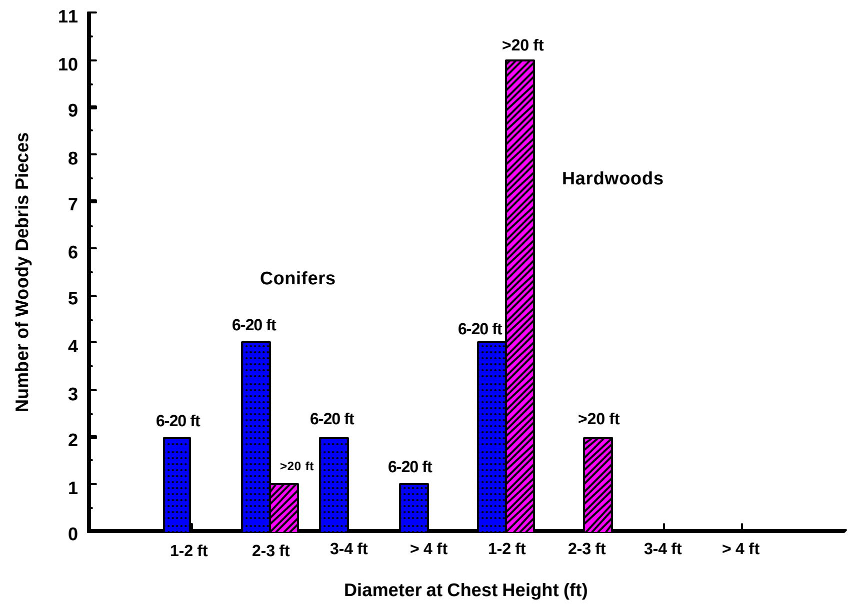
FIGURES

Figure 1. Inventory of Large, In-Channel Woody Debris (Coniferous and Hardwood) in Reach 1 (Partial- 7,519 ft) of Gazos Creek, 2001.



* "In-channel" in this context refers to the low-flow, wetted channel in summer.

Figure 2. Inventory of Large, In-Channel Woody Debris (Coniferous and Hardwood) in Reach 2 (4,437 ft) of Gazos Creek, 2001.

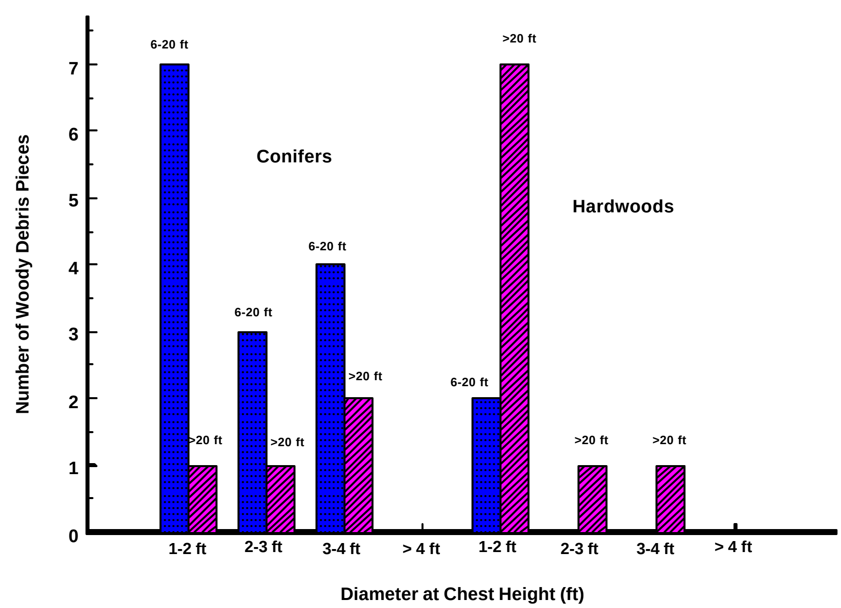
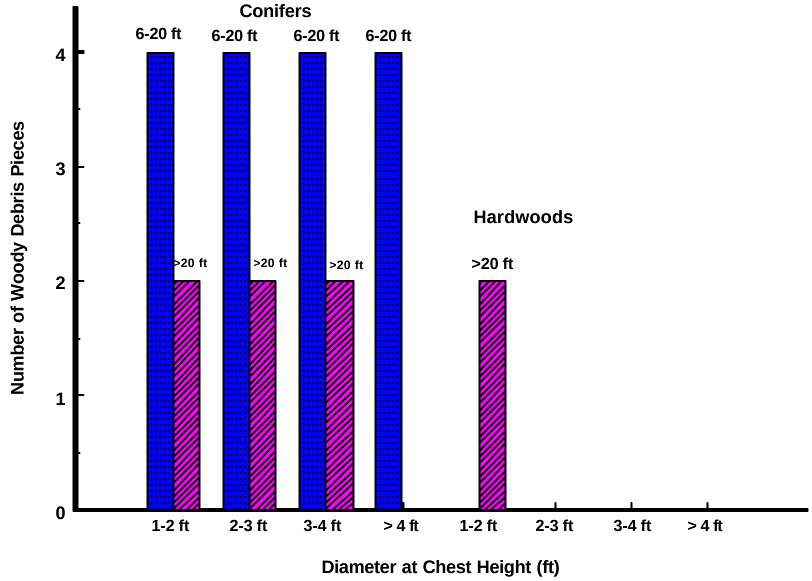


Figure 3. Inventory of Large, In-Channel Woody Debris (Coniferous and Hardwood) in Reach 3 (1,779 ft) of Gazos Creek, 2001.



* "In-channel" in this context refers to the low-flow, wetted channel in summer.

Figure 4. Inventory of Large, In-Channel Woody Debris (Coniferous and Hardwood) in Reach 4 (876 ft) of Gazos Creek, 2001.

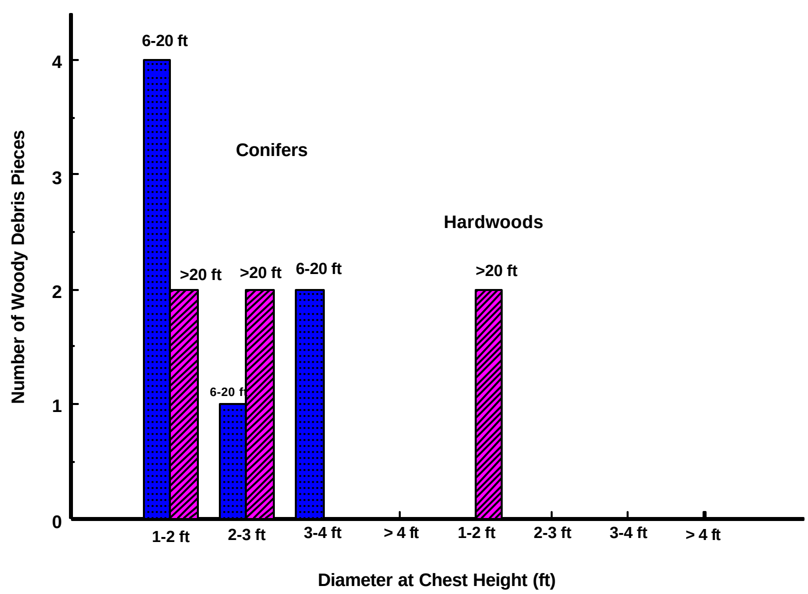
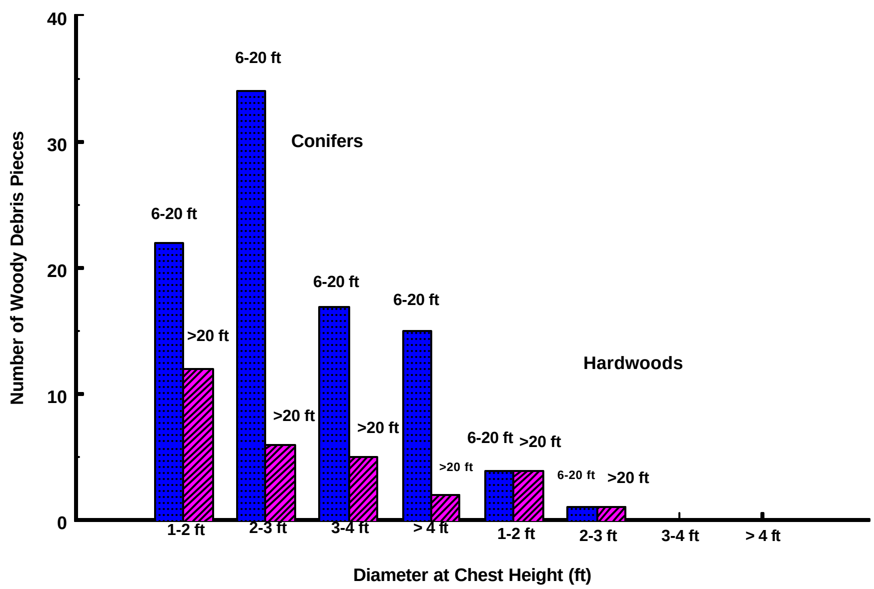


Figure 5. Invetory of Large, In-Channel Woody Debris (Coniferous and Hardwood) in Reach 5A-B (7,618 ft) of Gazos Creek, 2001.



* “In-channel” in this context refers to the low-flow, wetted channel in summer.

Figure 6. Inventory of Large, In-Channel Woody Debris (Coniferous and Hardwood) in Reach 5C (3,946 ft) of Gazos Creek, 2001.

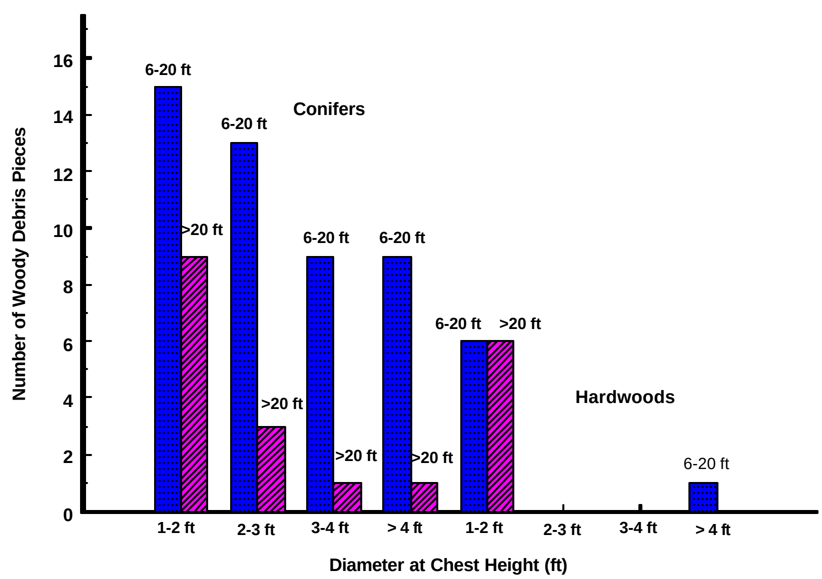
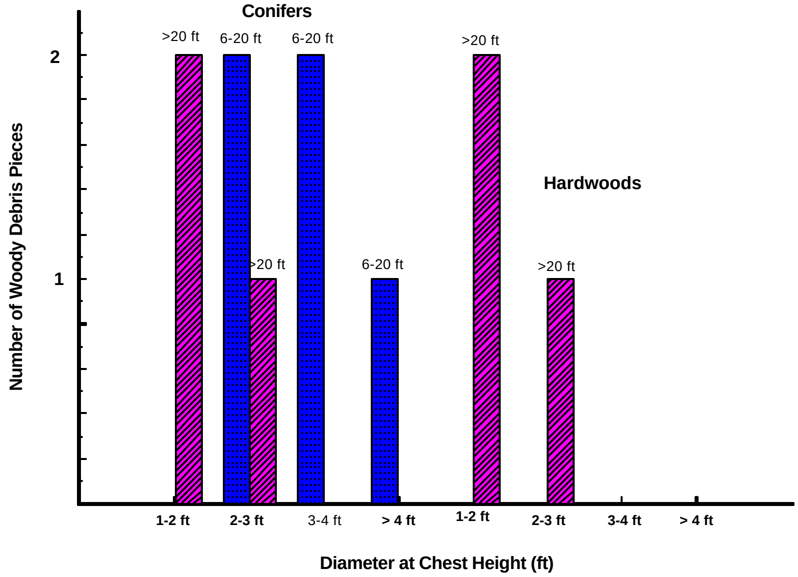
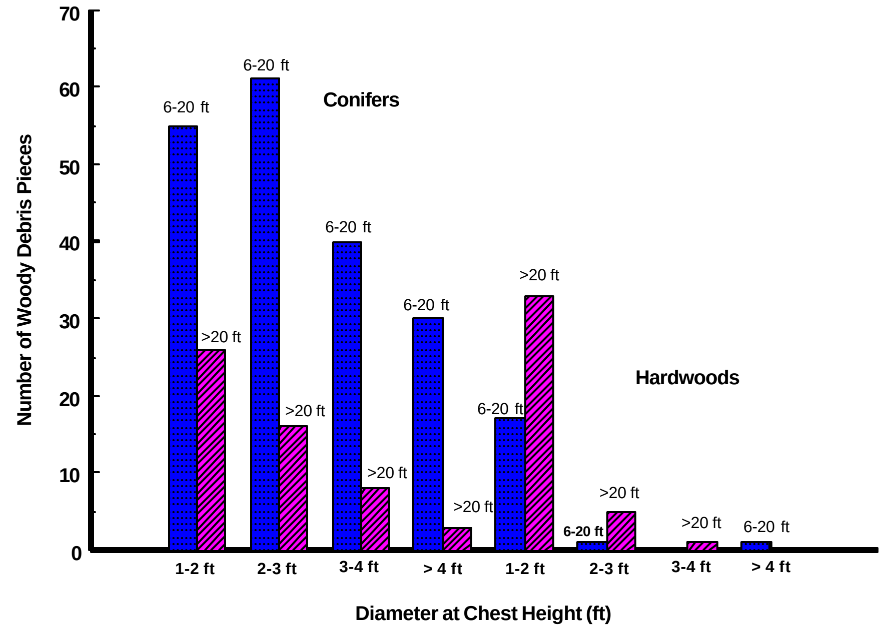


Figure 7. Inventory of Large, In-Channel Woody Debris (Coniferous and Hardwood) in Reach 6 (2,355 ft) of Gazos Creek, 2001.



* "In-channel" in this context refers to the low-flow, wetted channel in summer.

Figure 8. Inventory of Large, In-Channel Woody Debris in Surveyed Reaches (29,511 ft) of Gazos Creek, 2001.



* "In-channel" in this context refers to the low-flow, wetted channel in summer.

Figure 9. Pool Depth Measured as Mean Average and Maximum Depth in Gazos Creek and South Fork Reaches in 2001 Compared to San Lorenzo Tributary Reaches in 2000.

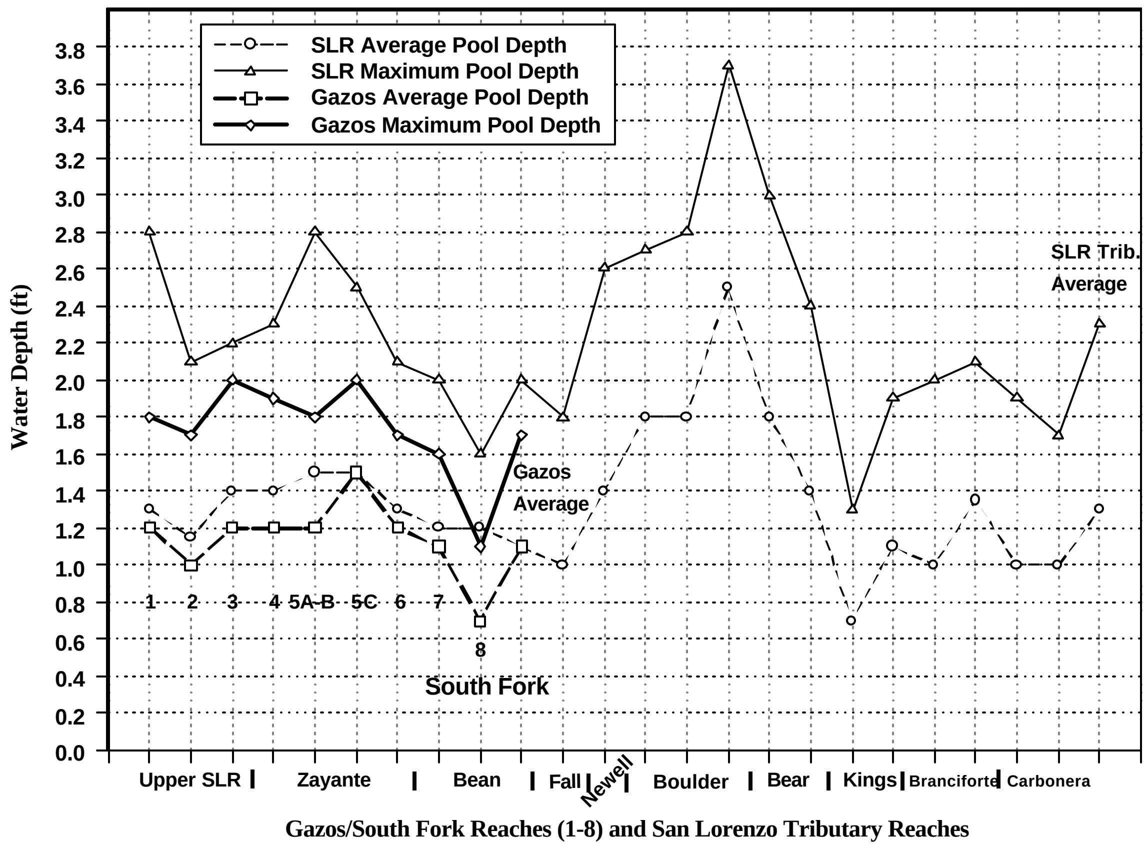


Figure 10. Pool Escape Cover Index as the Ratio, Cover (Linear Feet) Divided by Pool Habitat (ft) per Reach for Gazos/South Fork Reaches in 2001 Compared to San Lorenzo Tributary Reaches in 2000.

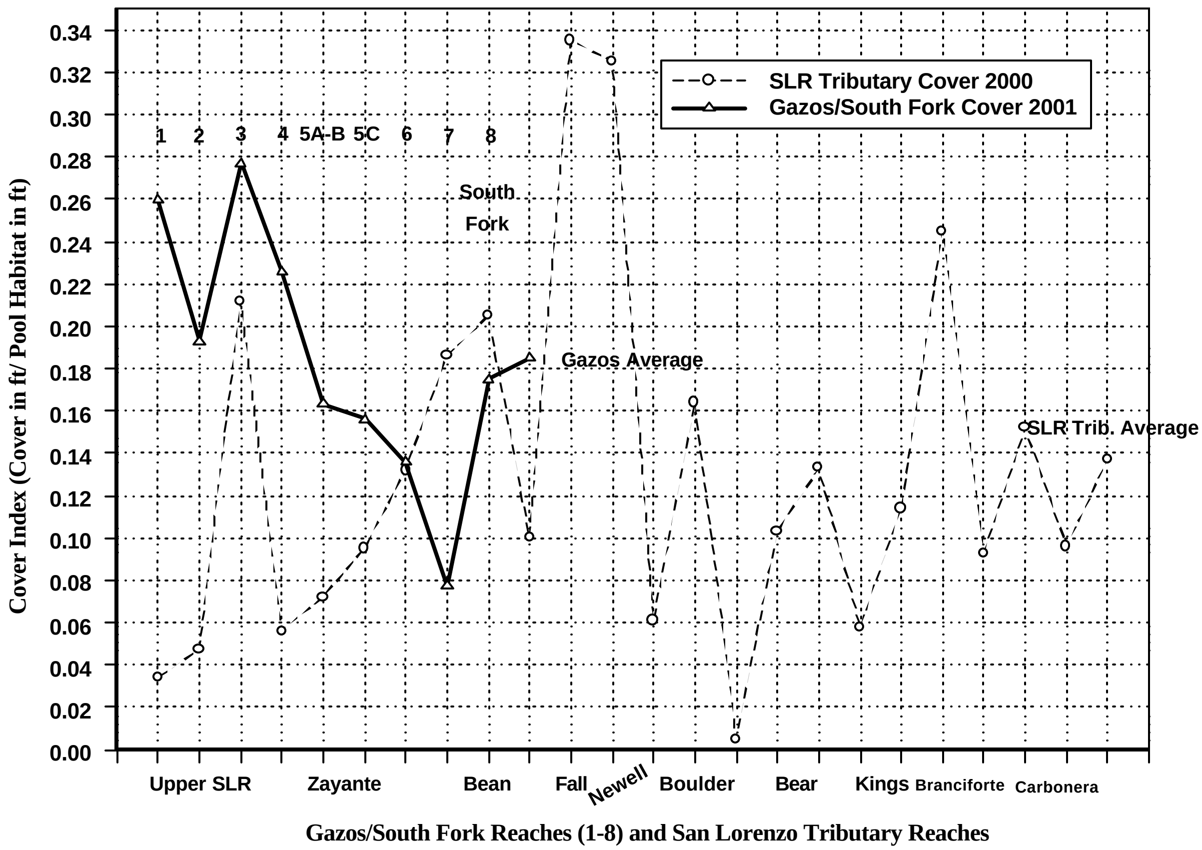


Figure 11. Reach Averages of Percent Fine Sediment in Pools in Gazos/ South Fork in 2001 Compared to San Lorenzo Tributaries in 2000.

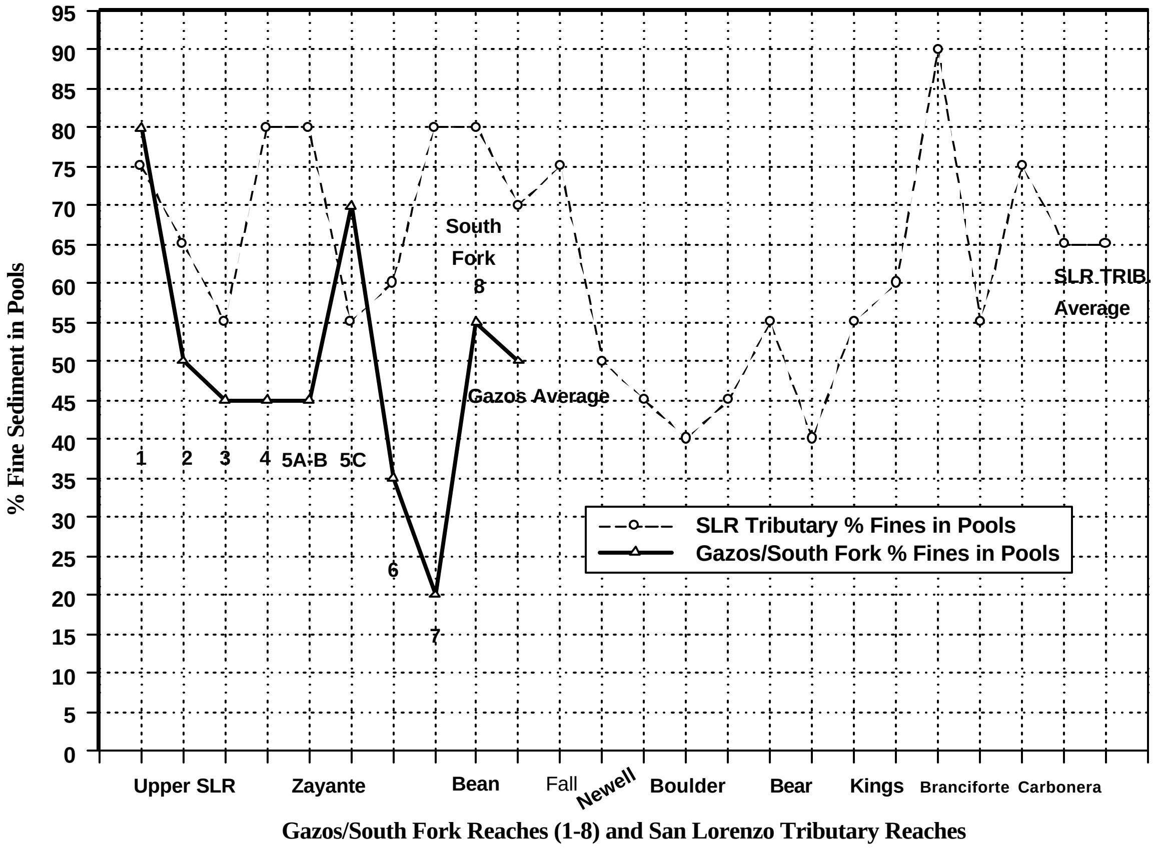


Figure 12. Reach Averages of Percent Fine Sediment in Potential Spawning Glides in Mainstem Gazos Creek in 2001 and in Mainstem/ East Branch Soquel Creek in 2002. (Percent fines estimated visually from hand-grab samples.)

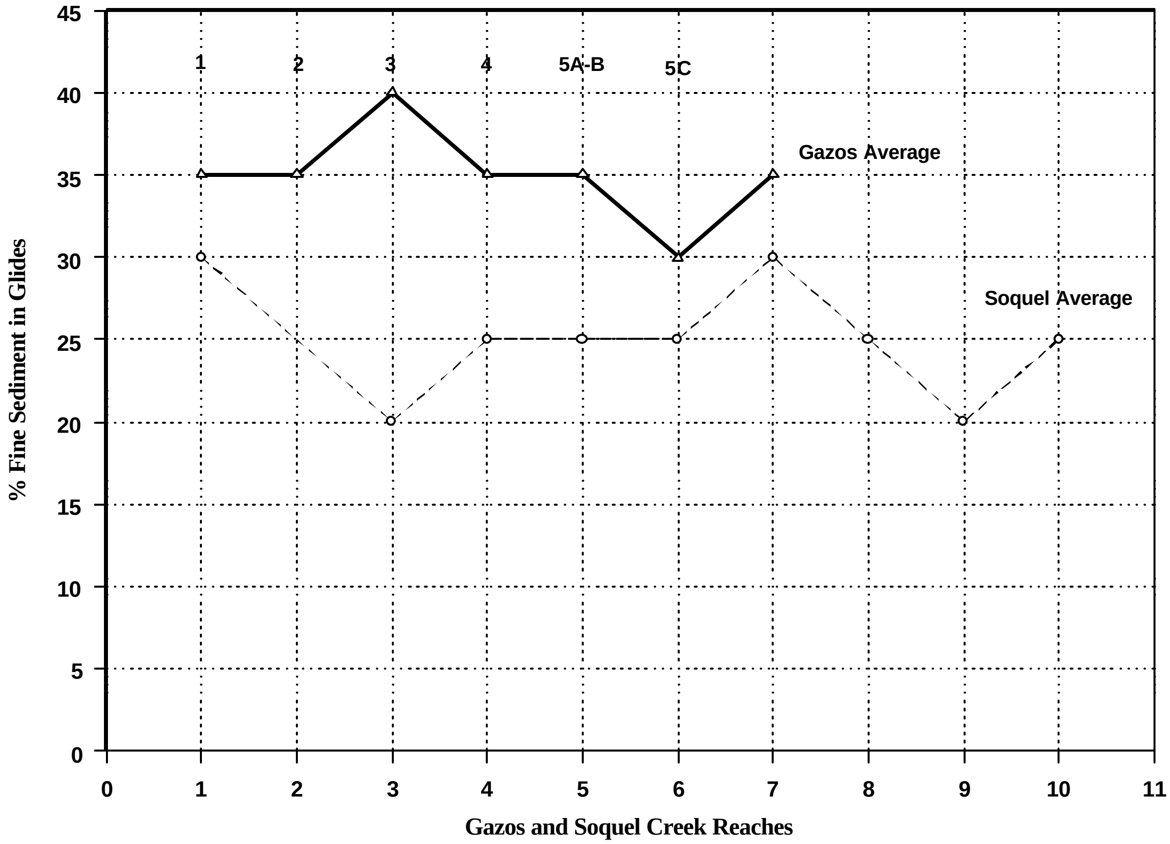


Figure 13. Average Pool Embeddedness in Gazos Creek and South Fork Reaches in 2001 Compared to San Lorenzo Tributary Reaches in 2000.

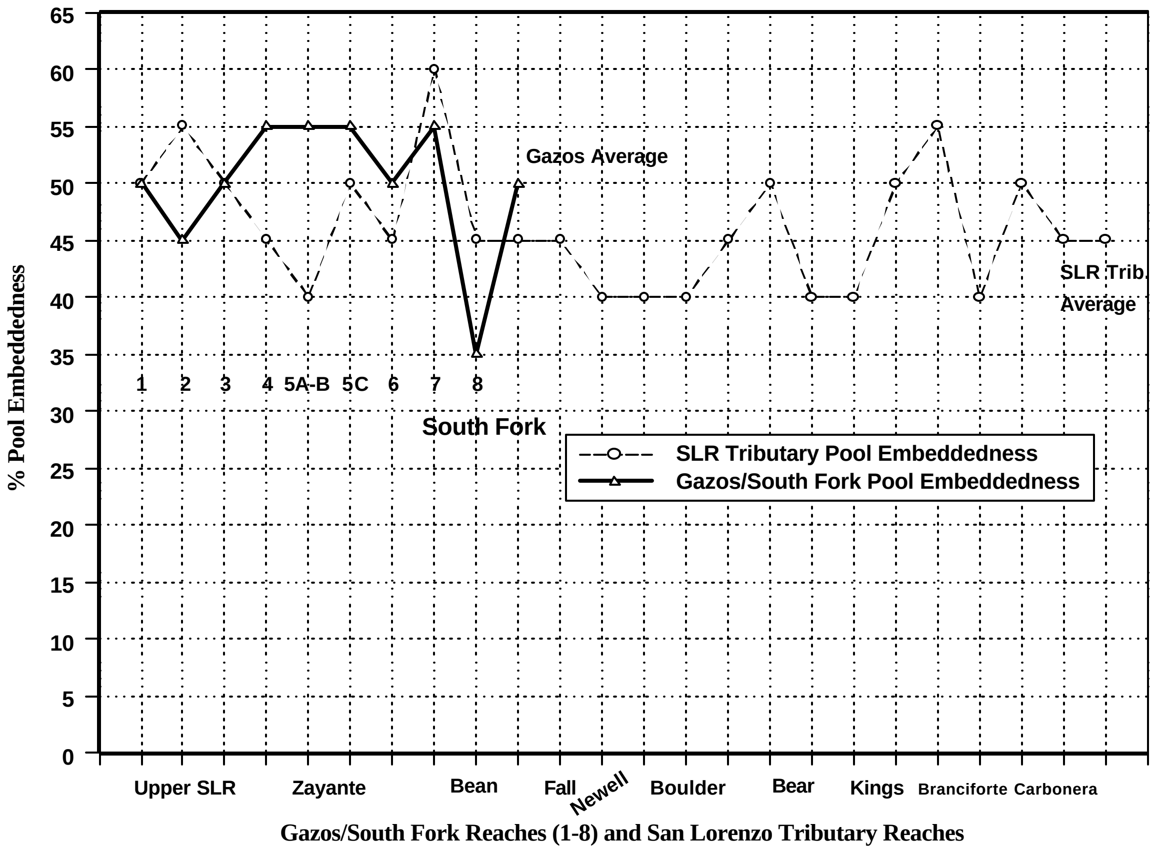


Figure 14. Average Riffle and Run Embeddedness in Gazos Creek and South Fork Reaches in 2001 Compared to San Lorenzo Tributary Reaches in 2000.

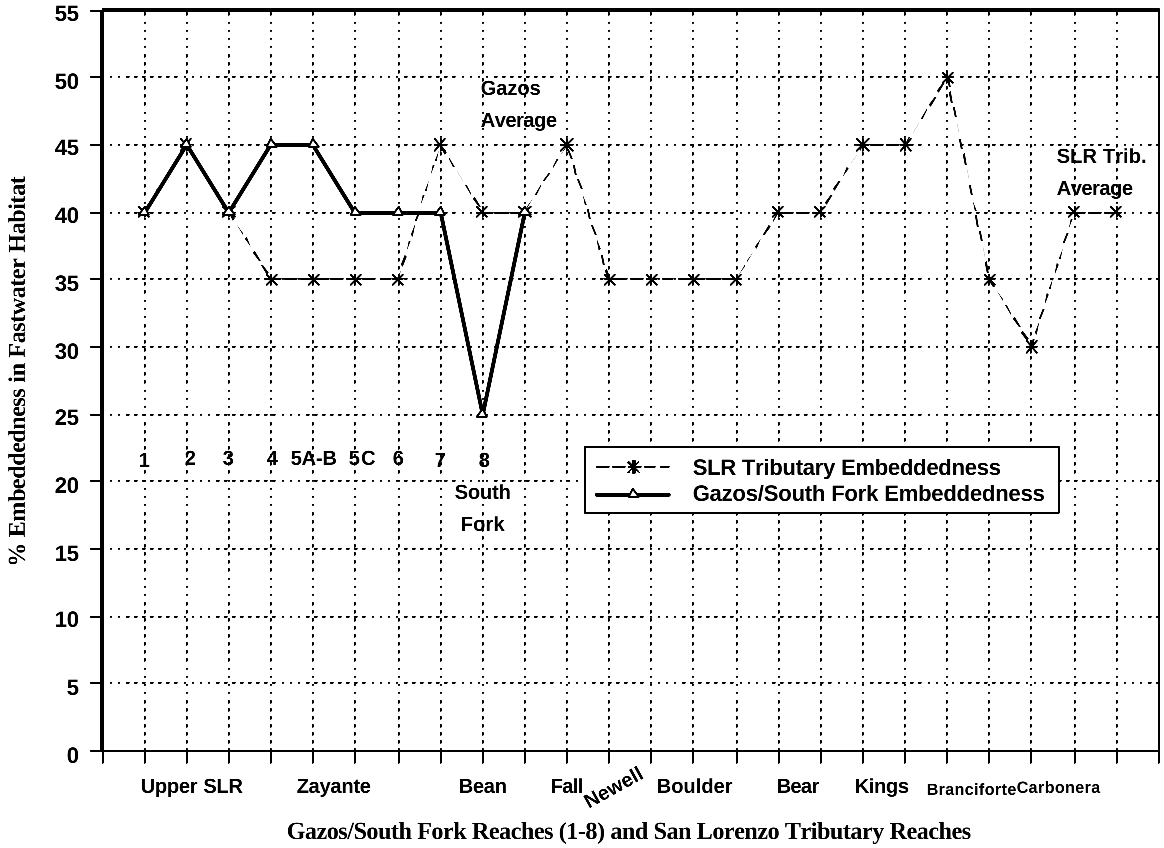


Figure 15. Frequency Histogram of Subsampled Mainstem Gazos Creek Pools Segregated by Linear Feet of Escape Cover per Pool for Rosgen "C" Channels Combined and Rosgen "B" Channels Combined, 2001.

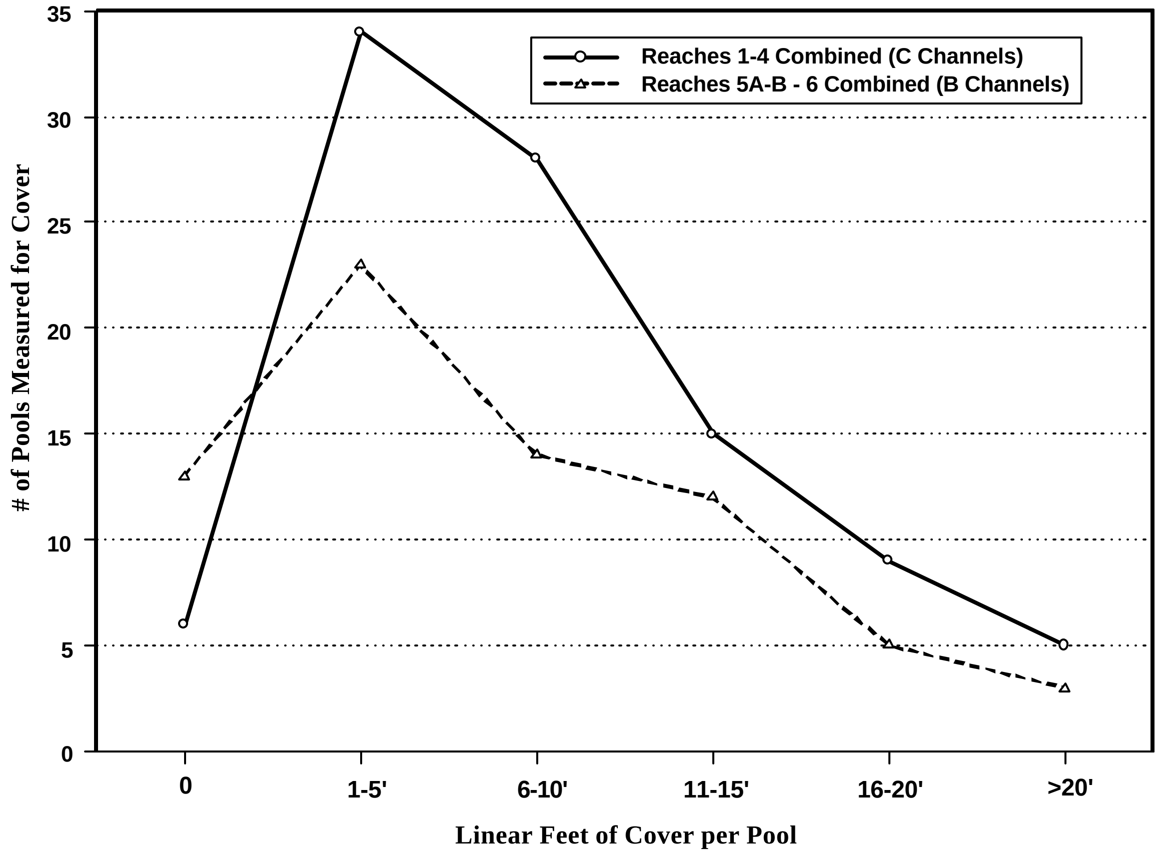


Figure 16. Gazos Creek Streamflow in Late Spring and Late Summer, 2001. (Data Collected by Coastal Watershed Council.)

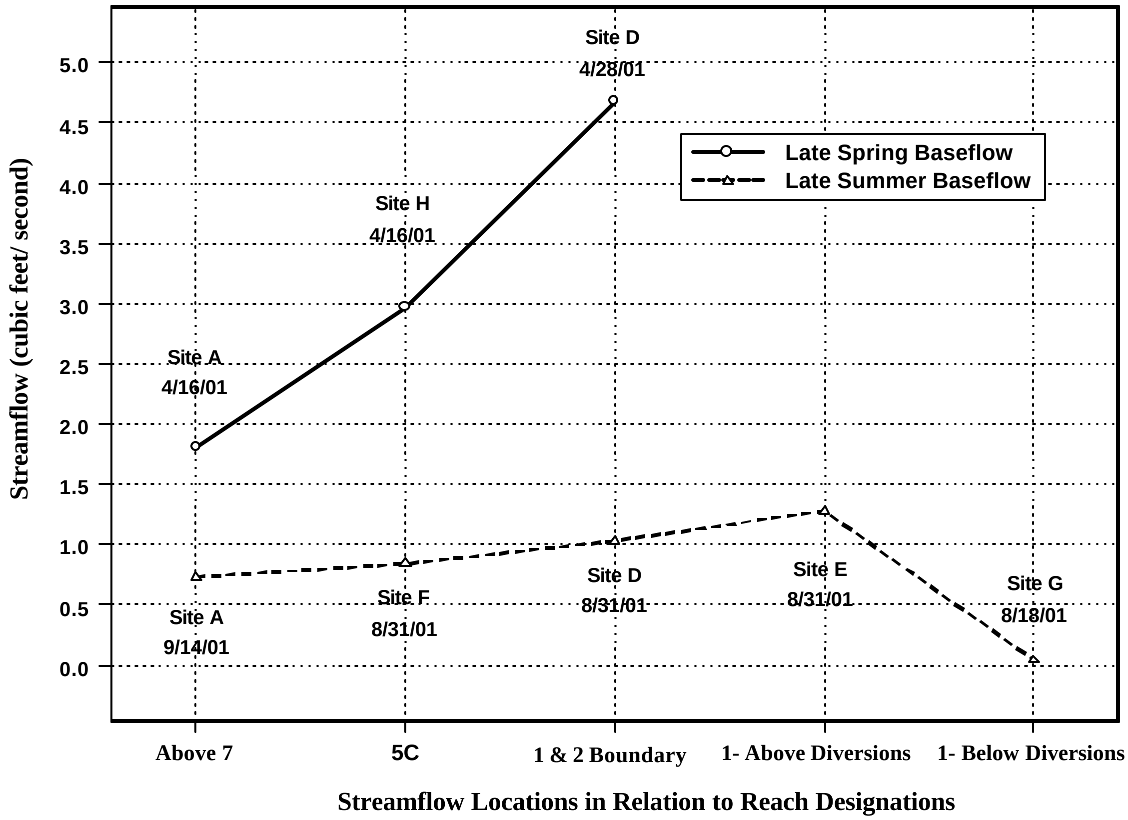


Figure 17. Streamflow Measured by Flowmeter at Fall Sampling Sites in Tributaries to the San Lorenzo River in 1995-96 and 1998-2001.

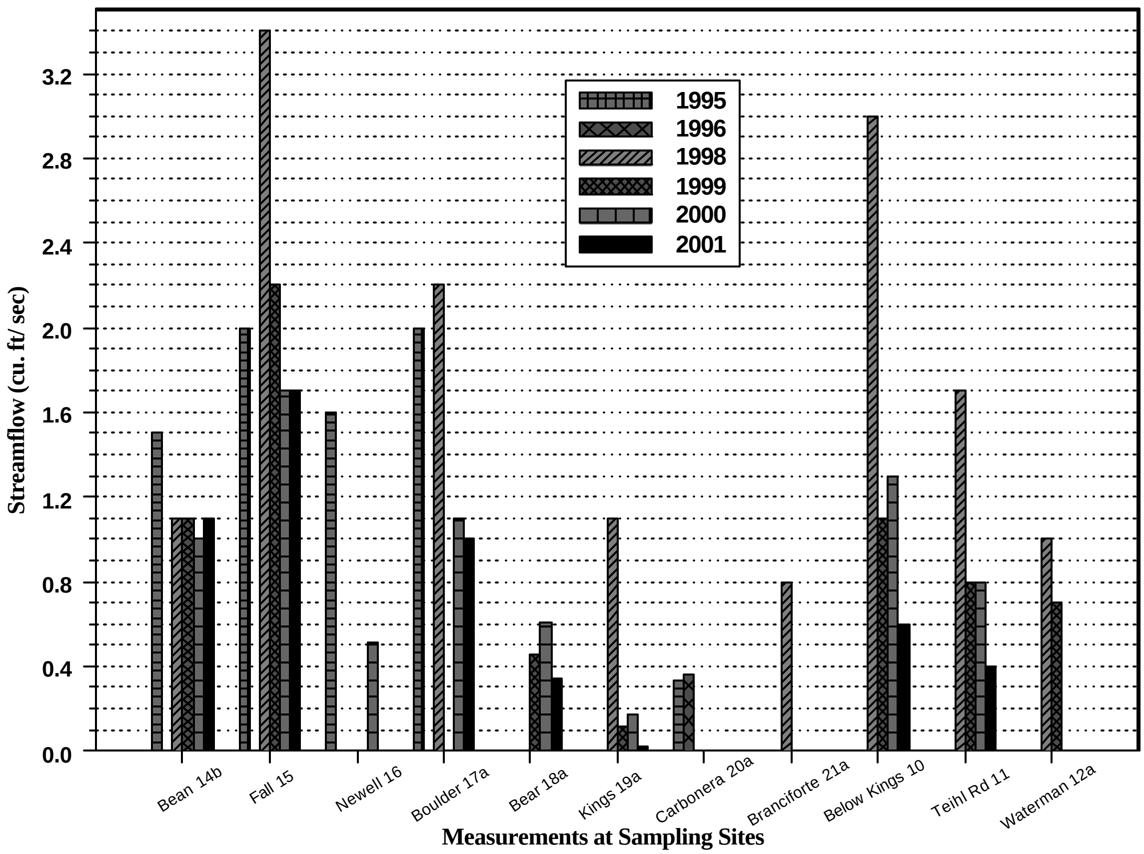


Figure 18. Estimated Fall Streamflow in Soquel Creek in 1997-2001.

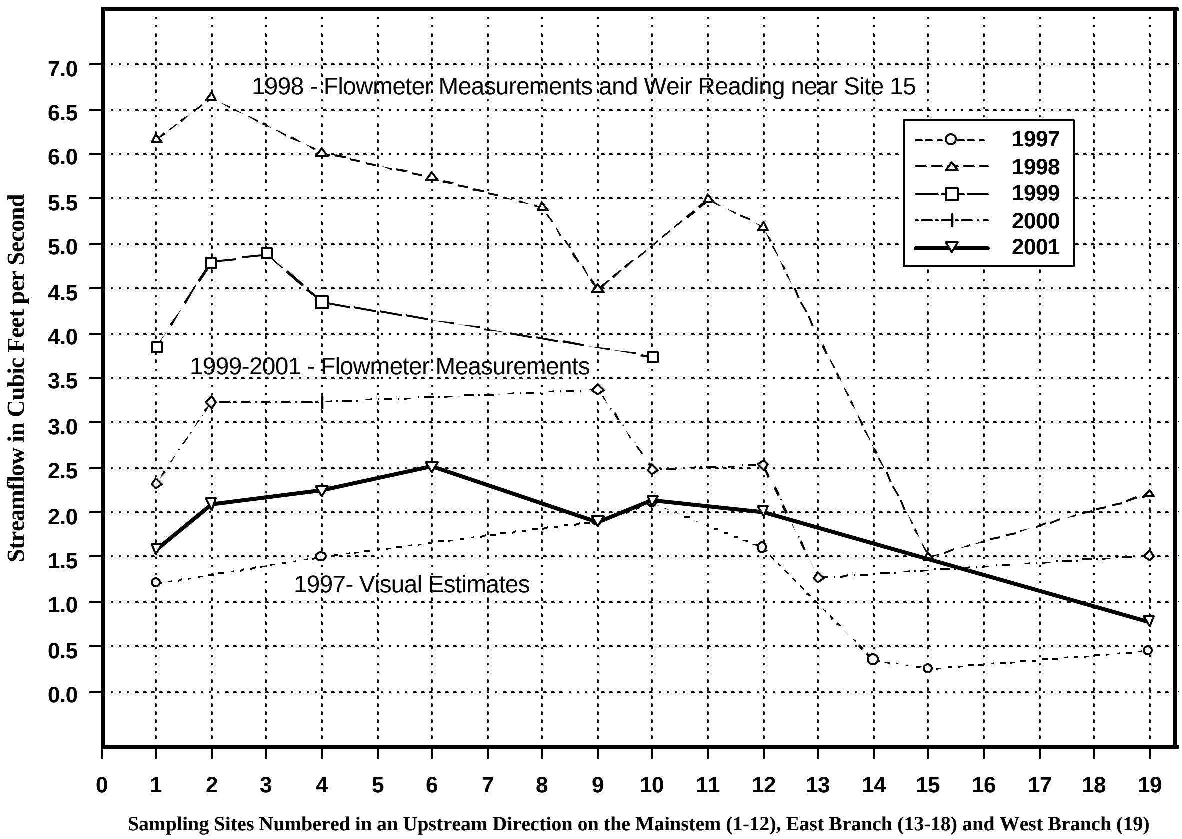


Figure 19. Percent Tree Canopy Closure Over Gazos Creek and Percent Deciduous Contribution to the Canopy Closure.

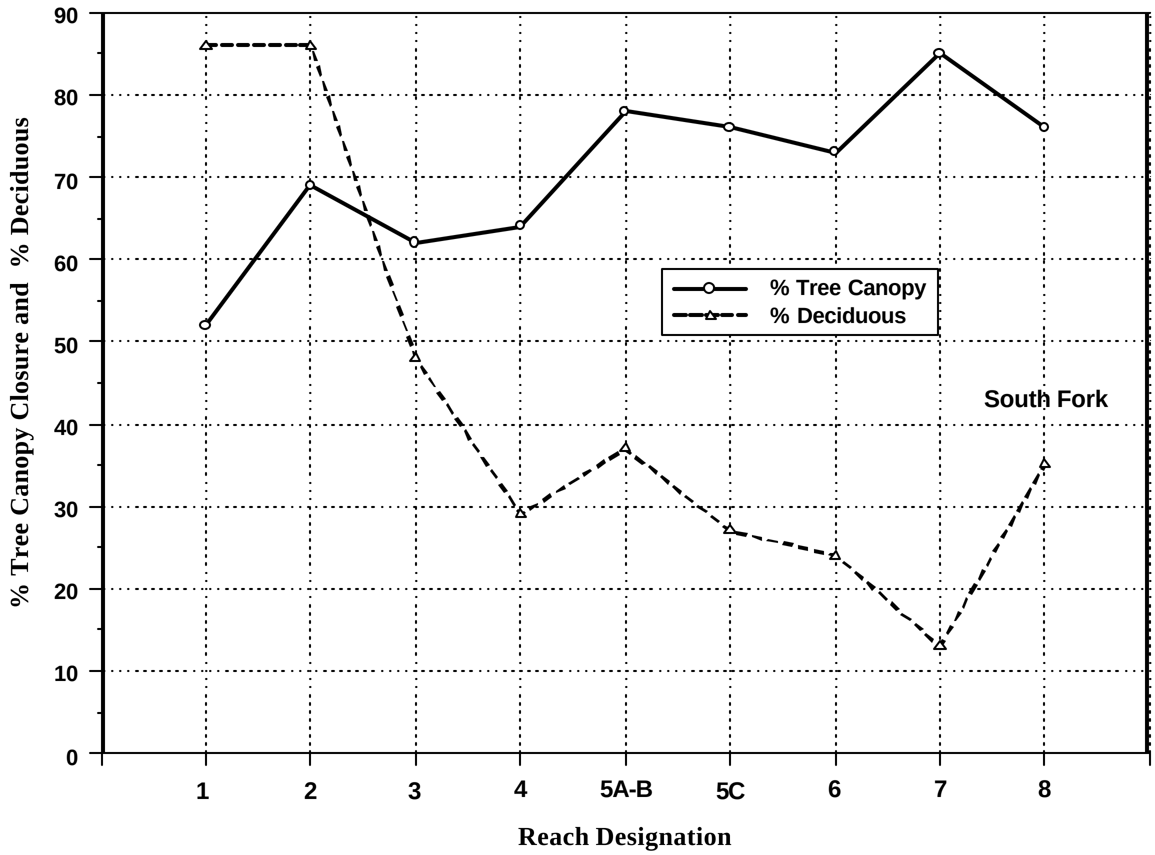


Figure 20. Average Percent Tree Canopy Closure at Sampling Sites Along Soquel Creek in 1994, 1997-99 and 2001.

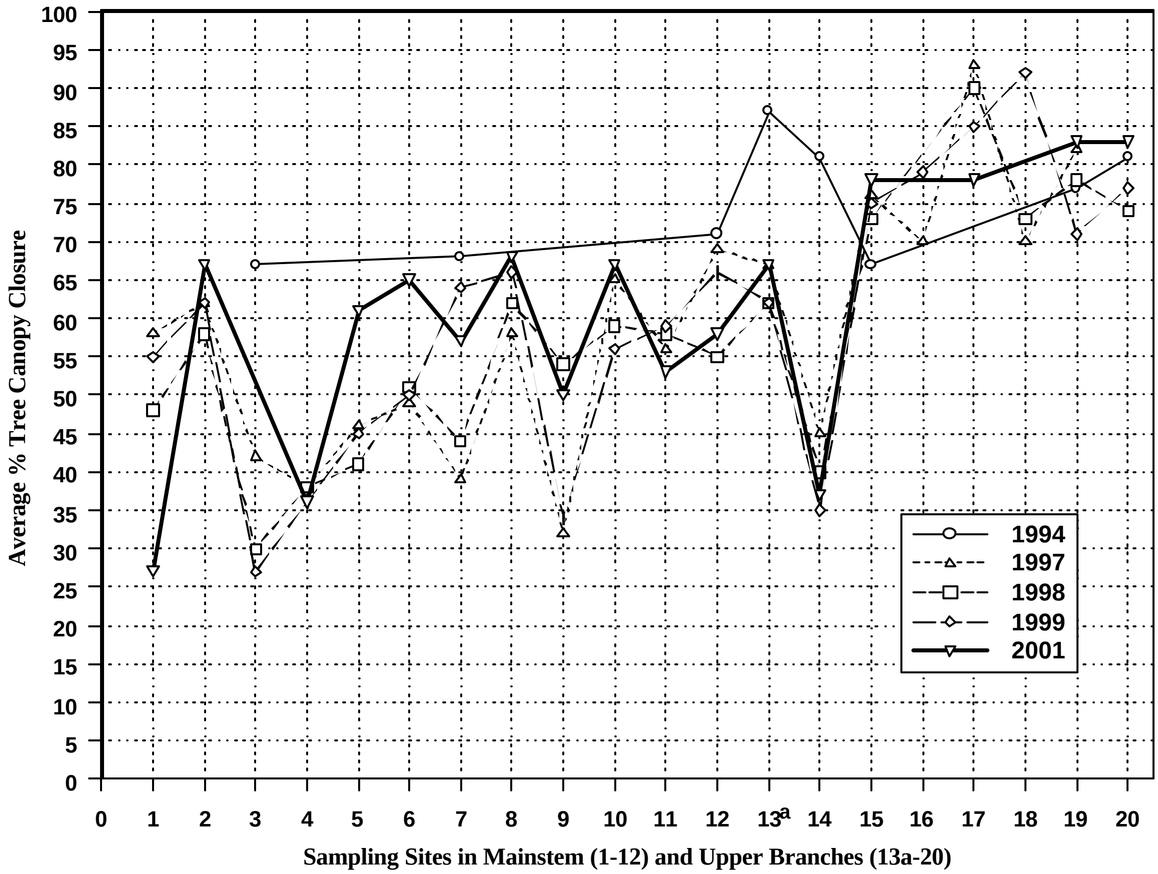


Figure 21. Gazos Creek Juvenile Steelhead Densities for 1999-2001. (Data from Smith, 2001).

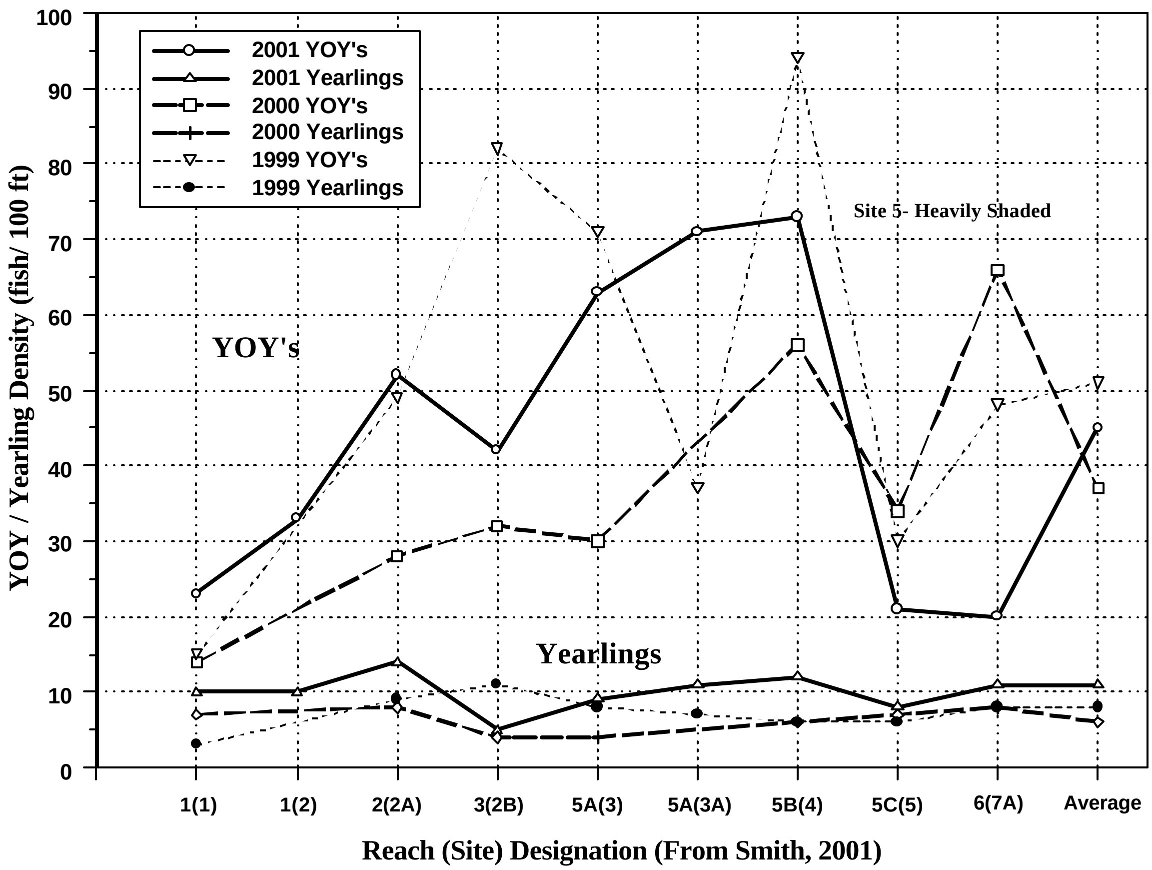
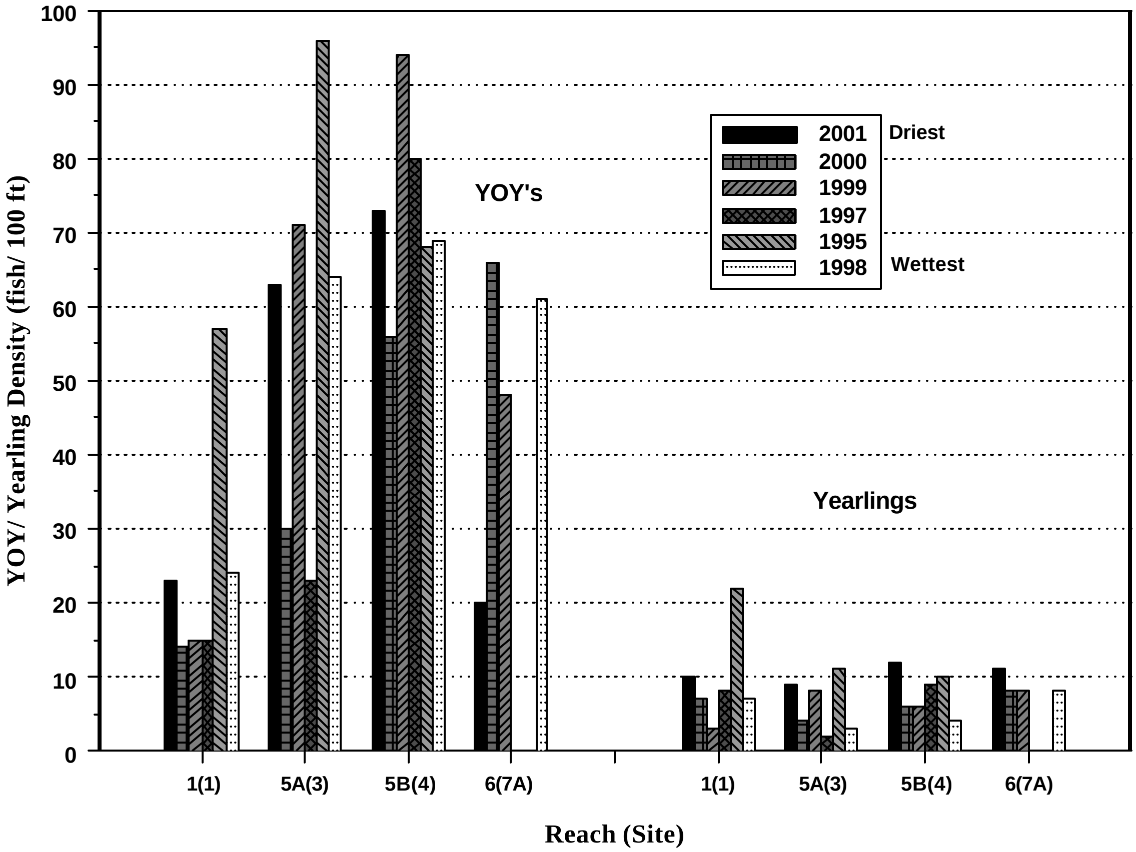


Figure 22. Gazos Creek Juvenle Steelhead Densities for 1995 and 1997-2001, Arranged by Increasing Annual Rainfall. (Data from Smith, 2001.)



APPENDIX A. PHOTO-DOCUMENTATION OF EROSION SITES AND ADULT SALMONID PASSAGE IMPEDIMENTS/ BARRIERS IN GAZOS CREEK, 2001.

(Available Separately Upon Request.)